



# Canadian National Report for the Convention on Nuclear Safety

Fifth Report  
September 2010



Government  
of Canada

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du Canada

Canada 

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# Canadian National Report on Nuclear Safety Fifth Report

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

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## Executive Summary

During the reporting period, nuclear power continued to play an important part in Canada's energy mix and economy. Seventeen CANDU reactors were operating at the end of the reporting period. The life extension of reactors at Bruce A and Point Lepreau continued, and the option of refurbishing other currently operating nuclear power plants (NPPs) was considered. During the reporting period, two licence applications to build new NPPs in Canada, which were previously reported in the fourth Canadian report, were withdrawn. However, the environmental assessment process was initiated with respect to an application for a licence to prepare site for a new-build project proposed for the Darlington site in Ontario.

This fifth Canadian report demonstrates how Canada continues to meet its obligations under the terms of the *Convention on Nuclear Safety* (the Convention), for the April 2007–March 2010 reporting period. During this reporting period, Canada effectively maintained — and in many cases enhanced — its measures to meet its obligations under the Convention. Enabled by a modern and robust legislative framework, these measures are implemented by a regulator and NPP licensees that focus on the health and safety of persons and the protection of the environment.

Canada remains fully committed to the principles and implementation of the Convention.

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 most important legislation is the *Nuclear Safety and Control Act* (NSCA). The legislation is complemented by regulations and other regulatory instruments that are developed in consultation with stakeholders. 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 uses a comprehensive compliance program to assure compliance with the regulatory framework and monitor the safety performance of the NPPs. The Canadian NPP licensees fulfill their responsibility to safety, and give it high priority at every level of their organizations. The CNSC and the licensees both make a strong ongoing commitment to nuclear safety, and strive to continuously improve.

The Canadian regulatory framework, which is largely non-prescriptive, is being continuously updated and aligned with international standards (as a minimum). Amendments and renewals of operating licences for NPPs have been used to introduce new standards and requirements. During the reporting period, the CNSC made significant progress in developing the regulatory

framework for two key areas — refurbishment and new-build. The CNSC further enhanced its readiness for new-build projects, by optimizing its employment levels, beginning work on the compliance program and skill sets needed to inspect and oversee new-build projects, and conducting vendor pre-project design reviews, as well as developing staff review procedures to aid in the assessment of submissions in support of licence applications.

Three other regulatory initiatives — licensing basis definition, reformed licence, and licence condition handbook — have helped improve the clarity of requirements and expectations for NPP licensees, and have also facilitated increased regulatory efficiency and effectiveness.

The International Atomic Energy Agency (IAEA) Integrated Regulatory Review Services completed a full-scope mission to Canada in June 2009. The findings from the mission report provided excellent feedback to the CNSC, and have helped inform the CNSC's ongoing improvement initiatives.

Canada has a mature nuclear industry, with an excellent safety record. During the reporting period, licensees fulfilled the basic responsibilities for safety as required by the NSCA, regulations, and their licences. Safety issues that arose were addressed by licensees to keep the risk at their NPPs at reasonable levels. Canadian NPP licensees also collaborated on many projects to address safety issues and share information.

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. All events were assessed as level “0” or “1” on the International Nuclear Event Scale (INES). The licensees' efforts to address these 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 all NPPs were kept at approximately 1% of derived release limits.

CNSC ratings of NPP safety performance under the CNSC safety areas confirmed that regulatory requirements and performance expectations in all safety areas were met or exceeded at all NPPs for all three years of the reporting period, with only a very small number of exceptions. In those few safety areas where CNSC expectations were not met, the licensees implemented corrective action plans to address deficiencies.

During the reporting period, the nuclear industry and CNSC addressed the seven specific challenges that were identified for Canada at the Fourth Review Meeting of the Convention.

#### Challenge C-1: Continue the Refurbishment Activities

Refurbishment work at Bruce Units 1 and 2 and Point Lepreau during the reporting period included replacements, modifications, and enhancements for safety-significant systems that will

improve safety performance. Extensive regulatory oversight was conducted, and the regulatory framework for life extension projects was also strengthened.

Challenge C-2: Reassure the Environmental Qualification of Safety and Safety-related Systems

During the reporting period, dedicated programs evolved at the Canadian NPPs to sustain and update (as necessary) the environmental qualification of safety and safety-related systems.

Challenge C-3: Plan and Implement Severe Accident Management Guidelines (SAMG) and Plan and Conduct Validation Exercises

The licensees continued to issue relevant procedures, began training their operations and emergency response staff, and began validation exercises in preparation for integrating SAMG into emergency preparedness programs.

Challenge C-4: Establish and Pursue a Success Path for Large-break Loss of Coolant Accident (LBLOCA) Safety Margin

Issues associated with LBLOCA safety margins are being systematically resolved in a larger exercise to resolve CANDU safety issues. LBLOCA was included in a comprehensive list of issues that were examined, risk-ranked, and for which potential risk control measures were identified. Issues related to LBLOCA were assigned to the group of Category 3 issues, which have measures in place to maintain safety margins, but the adequacy of these measures need to be confirmed. A preferred set of risk control measures (composite analytical approach) is being pursued to resolve the LBLOCA-related issues. A back-up option (design change strategy) is being developed in parallel.

Challenge C-5: Continue Discussions on Possible Implementation of Periodic Safety Review (PSR)

CNSC staff continued to consult NPP licensees and evaluate the implications of incorporating PSR in the NPP licensing process. It concluded that adopting PSR would result in some benefits with respect to regulatory oversight. Several key initiatives were completed that will facilitate the implementation of PSR if the decision is made to proceed; these include definition of the licensing basis, improvements to operating licence, increased use of risk-informed decision making, and the maturation of licensees' management systems. It is expected that the Commission Tribunal will deliberate the possible application of PSR in Canada in the next reporting period and consider factors such as the frequency of public access to the licensing process, effectiveness and efficiency, and the additional burden on the CNSC and licensees.

Challenge C-6: Implement More Fully the Risk-informed Decision Making Process

The risk-informed decision making process was revised and enhanced, and is now being used increasingly for a variety of regulatory decisions and situations.

Challenge C-7: Plan for an IRRS Mission with Expanded Scope

The scope of the IRRS mission was expanded beyond NPPs, to cover all facilities and activities licensed by the CNSC, with the exception of import/export. The mission to Canada was conducted in June 2009; the subsequent mission report identified a number of good practices and

made recommendations and suggestions that have helped shape improvement initiatives at the CNSC.

Many safety improvements, beyond those associated with the initiatives to address the seven challenges from the Fourth Review Meeting, were implemented at the NPPs during the reporting period. In particular, the life extension projects include many replacements, modifications, and enhancements of safety-significant systems that will improve system performance and monitoring, response to accident scenarios, and some safety margins. New equipment (such as passive autocatalytic recombiners, which can control hydrogen accumulation in containment during accidents) is being installed in reactors undergoing refurbishment.

## Table of Contents

<b>Executive Summary .....</b>	<b>i</b>
<b>Acronyms, Abbreviations and Specific Expressions.....</b>	<b>vii</b>
<b>Chapter I – Introduction .....</b>	<b>1</b>
<b>Chapter II – Summary .....</b>	<b>11</b>
<b>Chapter III – Compliance with Articles of the Convention.....</b>	<b>17</b>
<b>PART A General Provisions .....</b>	<b>17</b>
<b>Article 6 – Existing Nuclear Power Plants.....</b>	<b>18</b>
6 a    List of existing nuclear power plants .....	18
6 b    Justification of continued operation of Canadian NPPs .....	18
<b>PART B Legislation and Regulation.....</b>	<b>21</b>
<b>Article 7 – Legislative and Regulatory Framework.....</b>	<b>22</b>
7.1    Establishing and Maintaining a Legislative and Regulatory Framework .....	22
7.2    Provisions of the Legislative and Regulatory Framework.....	26
7.2 (i)  National Safety Requirements and Regulations .....	27
7.2 (ii)  System of licensing .....	32
7.2 (iii)  System of Regulatory Inspection and Assessment .....	46
7.2 (iv)  Enforcement.....	51
<b>Article 8 – Regulatory Body.....</b>	<b>55</b>
8.1    Establishment of the Regulatory Body .....	59
8.2    Status of the Regulatory Body .....	76
<b>Article 9 – Responsibility of the Licence Holder.....</b>	<b>80</b>
<b>PART C General Safety Considerations.....</b>	<b>84</b>
<b>Article 10 – Priority to Safety .....</b>	<b>85</b>
<b>Article 11 – Financial and Human Resources .....</b>	<b>91</b>
11.1    Adequacy of Financial Resources.....	91
11.2    Adequacy of Human Resources.....	92
<b>Article 12 – Human Factors.....</b>	<b>101</b>
<b>Article 13 – Quality Assurance .....</b>	<b>108</b>
<b>Article 14 – Assessment and Verification of Safety .....</b>	<b>112</b>
14 (i)    Assessment of Safety .....	112
14 (ii)   Verification of Safety.....	122
<b>Article 15 – Radiation Protection .....</b>	<b>128</b>
<b>Article 16 – Emergency Preparedness .....</b>	<b>134</b>





16.1	Emergency Plans and Programs.....	134
16.2	Information to the Public and Neighbouring States.....	139
16.3	Emergency Preparedness for Contracting Parties without Nuclear Installations ..	140
<b>PART D Safety of Installations.....</b>		<b>141</b>
<b>Article 17 – Siting.....</b>		<b>142</b>
17 (i)	Evaluation of Site-Related Factors .....	145
17 (ii)	Impact of the Installation on Individuals, Society and Environment.....	146
17 (iii)	Re-evaluation of Site Related Factors.....	147
17 (iv)	Consultation with Other Contracting Parties Likely to be Affected by the Installation.....	149
<b>Article 18 – Design and Construction .....</b>		<b>150</b>
18 (i)	Implementation of Defence-in-Depth in Design and Construction .....	153
18 (ii)	Incorporation of Proven Technologies.....	155
18 (iii)	Design for Reliable, Stable and Manageable Operation.....	156
<b>Article 19 – Operation .....</b>		<b>159</b>
19 (i)	Initial Authorization.....	159
19 (ii)	Operational Limits and Conditions.....	160
19 (iii)	Procedures for Operation, Maintenance, Inspection and Testing.....	163
19 (iv)	Procedures for Responding to Operational Occurrences and Accidents .....	164
19 (v)	Engineering and Technical Support.....	168
19 (vi)	Reporting Incidents Significant to Safety .....	169
19 (vii)	Operational Experience Feedback .....	169
19 (viii)	Management of Spent Fuel and Radioactive Waste on the Site .....	170
<b>APPENDICES .....</b>		<b>173</b>
<b>Appendix A Relevant Web Sites .....</b>		<b>174</b>
<b>Appendix B List and Status of Nuclear Power Plants in Canada .....</b>		<b>175</b>
<b>Appendix C Examples of Descriptions and Plans Required to Support an Application to Renew a Nuclear Power Plant Operating Licence.....</b>		<b>176</b>
<b>Appendix D Significant Events during Reporting Period.....</b>		<b>177</b>
<b>Appendix E Nuclear Safety Research in Canada Related to Nuclear Power Plants.....</b>		<b>183</b>
<b>Appendix F Description and Results of CNSC’s Assessment and Rating System for Nuclear Power Plants.....</b>		<b>189</b>
<b>Appendix G CANDU Safety Issues .....</b>		<b>195</b>
<b>Appendix H CNSC Risk-Informed Decision Making Process.....</b>		<b>202</b>
<b>ANNEXES .....</b>		<b>205</b>



## Acronyms, Abbreviations and Specific Expressions

<b>ACR</b>	Advanced CANDU Reactor
<b>action level</b>	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
<b>AECL</b>	Atomic Energy of Canada Limited
<b>ALARA</b>	as low as reasonably achievable, social and economic factors being taken into account.
<b>Bruce Power</b>	Bruce Power Inc.
<b>BDBA</b>	Beyond design basis accident
<b>Canadian report</b>	The [n <sup>th</sup> ] Canadian report refers to the [n <sup>th</sup> ] <i>Canadian National Report for the Convention on Nuclear Safety</i> , submitted on behalf of Canada for the [n <sup>th</sup> ] Review Meeting of the <i>Convention on Nuclear Safety</i>
<b>CANDU</b>	Canadian Deuterium Uranium
<b>CCP</b>	Commissioning control point
<b>CCS</b>	Concrete containment structure
<b>CEA Act</b>	<i>Canadian Environmental Assessment Act</i>
<b>CERTS</b>	Central Event Reporting and Tracking System
<b>CMD</b>	Commission Member Documents are prepared for Commission Tribunal hearings and meetings by CNSC staff, proponents and intervenors (each CMD is assigned a specific identification number)
<b>CNSC</b>	The Canadian Nuclear Safety Commission as an organization
<b>CNSC staff</b>	The staff of the Canadian Nuclear Safety Commission
<b>COG</b>	CANDU Owners Group Inc.
<b>Commission Tribunal</b>	The tribunal component of the Canadian Nuclear Safety Commission
<b>Convention</b>	<i>Convention on Nuclear Safety</i>
<b>CSA</b>	Canadian Standards Association
<b>DBA</b>	Design basis accident
<b>desktop review</b>	All verification activities limited to the review of documents and reports submitted by licensees (this includes quarterly technical reports, annual compliance reports, special reports and documentation related to design, safety analysis, programs and procedures)
<b>DPRR</b>	Directorate of Power Reactor Regulation
<b>DRL</b>	Derived release limits
<b>EA</b>	Environmental assessment
<b>ECC</b>	Emergency core cooling
<b>EIC</b>	Emergency information centre
<b>EIS</b>	Environmental impact statement
<b>EMA</b>	Emergency Management Act
<b>EMO</b>	Emergency Management Ontario
<b>event review</b>	All verification activities related to reviewing, assessing and

	trending of licensees' event reports.
<b>FNEP</b>	Federal Nuclear Emergency Plan
<b>focused inspection</b>	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
<b>G8</b>	Group of eight nations (Canada, United States of America, France, United Kingdom, Germany, Italy, Japan and Russia, and representatives of the European Union)
<b>GAI</b>	Generic action item
<b>GSS</b>	Guaranteed shutdown state
<b>Harmonized Plan</b>	The corporate improvement plan for the CNSC that integrates and aligns all cross-functional improvement initiatives into a single, prioritized plan with clear deliverables.
<b>HFE</b>	Human factors engineering
<b>HTS</b>	Heat transport system
<b>IAEA</b>	International Atomic Energy Agency
<b>INES</b>	International Nuclear Event Scale
<b>IRRS</b>	Integrated Regulatory Review Services
<b>IRS</b>	Incident reporting system
<b>ISR</b>	Integrated safety review
<b>ISTB</b>	Inter-station transfer bus
<b>IWST</b>	Injection water storage tank
<b>lay-up</b>	A special configuration into which a plant is placed to prevent system and component degradation during extended periods of shutdown
<b>LCH</b>	Licence condition handbook
<b>LOCA</b>	Loss of coolant accident
<b>LVR fuel</b>	Low void reactivity fuel
<b>LZCS</b>	Liquid zone control system
<b>mSv</b>	Millisievert
<b>MW</b>	Megawatt
<b>NBEMO</b>	New Brunswick Emergency Measures Organization
<b>NBPN</b>	New Brunswick Power Nuclear Corporation
<b>NEA</b>	Nuclear Energy Agency (an agency of the Organization for Economic Cooperation and Development)
<b>NPP</b>	Nuclear power plant
<b>NRCan</b>	Natural Resources Canada
<b>NSCA</b>	<i>Nuclear Safety and Control Act</i>
<b>OLC</b>	Operational limits and conditions
<b>OP&amp;P</b>	Operating policies and principles
<b>OPEX</b>	Operating experience
<b>OPG</b>	Ontario Power Generation Inc.
<b>OSCQ</b>	Organisation de sécurité civile du Québec
<b>PMUNE-G2</b>	Plan des mesures d'urgence nucléaire externe à la centrale Gentilly-2

<b>PNERP</b>	Province of Ontario Nuclear Emergency Response Plan
<b>PSA</b>	Probabilistic safety assessment
<b>PSR</b>	Periodic safety review
<b>QA</b>	Quality assurance
<b>R&amp;D</b>	Research and development
<b>reporting period</b>	April 2007 to March 2010
<b>RIDM</b>	Risk-informed decision making
<b>RPD</b>	Regulatory program division
<b>S-99</b>	CNSC regulatory standard <i>Reporting Requirements for Operating Nuclear Power Plants</i>
<b>SAMG</b>	Severe accident management guidelines
<b>SAT</b>	Systematic approach to training
<b>SOE</b>	Safe operating envelope
<b>SSCs</b>	Structures, systems and components
<b>TSSA</b>	Technical Standards and Safety Authority
<b>Type I Inspection</b>	All verification activities related to onsite audits and evaluations of licensee programs, processes and practices
<b>Type II Inspection</b>	All verification activities related to routine (item-by-item) checks and rounds
<b>UNENE</b>	University Network of Excellence in Nuclear Engineering
<b>UOIT</b>	University of Ontario Institute of Technology
<b>WANO</b>	World Association of Nuclear Operators



## Chapter I – Introduction

### A. *General*

Canada was one of the first signatories of the *Convention on Nuclear Safety* (the Convention), which came into force on October 24, 1996. Canada has endeavoured to fulfill its obligations under 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.

This fifth Canadian report was produced by a team led by the Canadian Nuclear Safety Commission (CNSC), on behalf of the Government of Canada. Contributions to the report were made by representatives from Bruce Power, Hydro-Québec, New Brunswick Power Nuclear, Ontario Power Generation, Atomic Energy of Canada Limited, Foreign Affairs and International Trade Canada, Natural Resources Canada, and the emergency response organizations of the provinces of New Brunswick, Ontario and Québec.

#### A.1 **Scope**

As required by Article 5 of the Convention, this fifth Canadian report demonstrates how Canada fulfilled its obligations under Articles 6 to 19 of the Convention during the reporting period, which extends from April 2007 to March 2010. The report follows closely the form and structure established by the Contracting Parties to the Convention, pursuant to Article 22, and the IAEA document *Guidelines Regarding National Reports under the Convention on Nuclear Safety* (INFCIRC/572/Rev.3), which was revised in September 2009. This fifth 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 fourth Canadian report. A particular focus is placed on the challenges identified for Canada at the Fourth Review Meeting. The progress on legacy issues identified for Canada at the Third Review Meeting is also addressed.

The nuclear installations referred to in the Articles of the Convention are taken to mean nuclear power plants (NPPs). Therefore, the Canadian report does not cover research reactors.

This report does not cover nuclear security and safeguards, nor does it cover spent fuel and radioactive waste, except for the discussion in subsection 19 (viii) of this report. Spent fuel and radioactive waste are addressed more thoroughly in the third *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 2008.

#### A.2 **Contents**

Chapter I of this report provides important context for the rest of the report. Section A of Chapter I is a general introduction. Section B summarizes the outcome of the Fourth Review Meeting for Canada, including the specific good practices and challenges that were identified for Canada. Section C describes aspects of nuclear power policy and nuclear-related activity in Canada. Section D provides a high-level, background description of the nuclear power industry in Canada and recent major developments (refurbishments and new-build projects). Although

these sections are not directly applicable to any particular article of the Convention, they represent the context within which the articles are met.

Chapter II of this report 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 Fourth Review Meeting
- progress on other important safety issues not covered by the challenges identified for Canada
- planned future activities to improve safety that will address the challenges identified for Canada and other safety issues

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 in each chapter begin with a grey box that contains the text of the relevant article of the Convention. For each article, the description of Canada's provisions to fulfill the relevant obligations is organized in subsections 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 numbering, for reference purposes.

In this report, the challenges and good practices identified for Canada at the Fourth Review Meeting are highlighted in boxes near the beginning of the relevant discussion.

In June 2009, Canada hosted a mission by the Integrated Regulatory Review Service (IRRS; see Article 8 for details). The findings from the *2009 IAEA Report on the Integrated Regulatory Review Service (IRRS) to Canada* are included in boxes, where appropriate, to provide complementary information regarding Canada's regulatory performance by an independent review team. The CNSC's responses to the IRRS findings are also provided in the boxes.

There are two bodies of supplementary information at the end of the report — appendices and annexes. The appendices (identified by letters A through H) 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. Each annex's number corresponds to the number of the article to which the annex is relevant.

The full text of the first, second, third and fourth Canadian reports, as well as related documents, can be found on the Web sites of the CNSC and the IAEA. A list of Web sites of relevant organizations mentioned throughout this report is included in Appendix A. The fifth Canadian report will be available on the CNSC Web site in 2011, in both of Canada's official languages



(English and French). The annual CNSC staff reports on the safety performance of the Canadian nuclear power industry, as well as the annual reports of the CNSC, can also be found on the CNSC Web site.

## ***B. Outcome of the Fourth Review Meeting***

At the Fourth Review Meeting of the Convention, held in Vienna in April 2008, Canada was part of Country Group 5, which also included Chile, Germany, Bulgaria, Luxembourg, Switzerland, and the Netherlands. Canada presented its report at the Fourth Review Meeting to an audience of more than 90 participants, representing 18 countries. Canada also responded to comments and questions from numerous country delegations, which included Finland, Korea, United States, Pakistan, Germany, Switzerland, Luxembourg, Ukraine, Turkey, India, United Kingdom, Chile and France. These comments and questions pertained to such topics as CNSC independence, refurbishment, new reactors, recruitment and retention strategies, risk-informed decision making, probabilistic safety assessment, large-break loss of coolant accidents (LBLOCA), the CNSC Internship Program, regulatory framework, cost recovery, severe accident management guidelines (SAMG), emergency preparedness, integrated safety review versus periodic safety review (PSR), generic action items, operating experience, reporting and performance indicators.

The following sections list the good practices and the challenges identified for Canada at the Fourth Review Meeting, as recorded in the Rapporteur's Summary Report for Country Group 5. Cross-references to the relevant subsections of the report are also provided. An outstanding issue, drawn to the attention of all Contracting Parties at the Fourth Review Meeting, is also described. In addition, legacy issues from the Third Review Meeting are also listed.

### **B.1 Good Practices for Canada**

#	Text of Good Practice	Relevant Subsection
G-1	Regulatory process is open and transparent to public, including stakeholders	7.2
G-2	Application of the risk-informed decision making approach, in particular for prioritization of safety issues and planning resource utilization	8.1 d
G-3	Establishment of an operational forum for high-level executive discussions between the regulator and the industry on policy issues and path forward	8.1 f
G-4	Conduct of the integrated safety review (which is similar to PSR approach) to decide on the scope of safety improvements, supporting refurbishment of nuclear reactors	14 (i) c
G-5	CANDU Owners Group, CANDU Senior Regulators Group, WANO, OPEX information exchange approach, including regular contact conferences	19 (vii)

### **B.2 Challenges for Canada**

#	Text of Challenge	Relevant Subsection
C-1	Continue the refurbishment activities	14 (i) c
C-2	Reassure the environmental qualifications of safety and safety-related systems	14 (ii) c

C-3	Plan and implement severe accident management guidelines (SAMG), and plan and conduct validation exercises	19 (iv)
C-4	Establish and pursue a success path for LBLOCA safety margin	14 (i)
C-5	Continue discussions on possible implementation of PSR	14 (i) d
C-6	Implement more fully the risk-informed decision making process	8.1 d
C-7	Plan for an IRRS mission with an expanded scope	8

### **B.3 Outstanding Issue for All Contracting Parties**

“Recent circumstances in Canada related to the operation of NRU revealed a challenge to all Contracting Parties — how to resolve the potential conflict between nuclear safety and need for uninterrupted production of goods and services which are essential for public safety or well-being, taking into account both Articles 8(2) and 10 of the Convention.”

This issue is addressed in subsection 8.2 b of this report.

### **B.4 Legacy Issues for Canada from the Third Review Meeting**

Besides addressing the above issues and challenges that were identified at the Fourth Review Meeting, Canada has also continued to address ongoing actions that were identified at the Third Review Meeting. The actions that were not specifically identified as challenges at the Fourth Review Meeting, but are still relevant, are listed here for reference. They are addressed in the appropriate part of the report.

- developing the regulatory approach for refurbishment and life extension of nuclear power plants (see subsection 7.2 (i) b)
- modernizing the regulatory framework for licensing new reactor projects (see subsection 7.2 (i) c)
- maintaining safety competence in the nuclear industry (see subsection 11.2 b) and the regulatory body (see subsection 8.1 c)
- completing the quality management program implementation in the regulatory body (see subsection 8.1d)
- improving the rating system used to evaluate licensee performance (see subsection 7.2 (iii) b)
- continuing the SOE projects at the NPPs (see subsection 19 (ii) b)

## ***C. National Nuclear Framework and Policy***

### **C.1 General Framework**

In Canada, the development and production of nuclear energy and nuclear substances falls within federal jurisdiction. The Government of Canada has funded nuclear research and has supported the development and the use of nuclear energy and related applications for many decades. The first nuclear power plant (NPP) in Canada began operation in 1962. Today, the Government of Canada funds research and development activities primarily related to Canadian Deuterium Uranium (CANDU) technology, in the amount of approximately \$100 million annually. In addition, the nuclear industry provides, via the CANDU Owners Group (COG; described in subsection D.1), approximately \$40 million annually for research that supports operating NPPs.

While the Government of Canada has important responsibilities relating to nuclear energy, the decision to invest in electric generation rests with the provinces. It is up to the provinces, in concert with the relevant provincial energy organizations/power utilities, to determine whether or not new NPPs should be built. The Government of Canada views nuclear energy as an important component of a diversified energy mix. It has taken necessary measures to ensure the long-term development of nuclear energy as a sustainable energy source in meeting existing and future energy requirements. The Canadian nuclear energy program is a very important component of Canada's economy and energy mix.

The following statements provide an overview of nuclear activity in Canada:

- On average, nuclear energy supplies about 15% of Canada's electricity.
- In the province of Ontario, 50% of electricity generation is from NPPs.
- Canada's nuclear technology has allowed the medical world to improve cancer therapy and diagnostic techniques (Canada is a major supplier to the world market for medical isotopes).
- Canada's CANDU reactors have been deployed in several countries; the list includes four in operation in South Korea, two in China and Romania, and one in Argentina.
- The country's entire nuclear industry, including power generation, contributes several billions of dollars a year to the gross domestic product, and creates more than 30,000 jobs that require highly skilled workers.
- Canada is the world's second largest supplier of uranium, which continues to rank among the top 10 metal commodities in Canada for value of production.

## C.2 National Nuclear Policy

By virtue of Canada's constitution, responsibility for nuclear energy falls within the jurisdiction of the federal government. Its role encompasses research and development, as well as the regulation of all nuclear materials and activities in Canada. The Government of Canada places high priority on health, safety, national security and the environment in relation to nuclear activities in Canada, and has established a comprehensive and robust regulatory regime. Canada's nuclear regulator is the Canadian Nuclear Safety Commission (CNSC), an independent federal agency. Other major federal government departments involved in the Canadian nuclear industry include the following:

- Natural Resources Canada (NRCan), which develops Canadian federal energy policy; administers the *Nuclear Energy Act*, the *Nuclear Liability Act*, and the *Nuclear Fuel Waste Act*; has overall responsibility for managing historic wastes; and is responsible for the *Nuclear Safety and Control Act* (NSCA), which is administered by the CNSC
- Health Canada, which establishes radiological protection standards and monitors occupational radiological exposures
- Transport Canada, which develops and administers policies, regulations and services for the Canadian transportation system including the transportation of dangerous goods
- Environment Canada, which contributes to sustainable development through pollution prevention, to protect the environment and human life and health from the risks associated with toxic substances; and which is responsible for administering the *Canadian Environmental Protection Act* and the *Canadian Environmental Assessment Act* and delegates partial administration thereof to the CNSC

- Foreign Affairs and International Trade Canada, which establishes and administers the nuclear non-proliferation policy implemented by the CNSC

The NSCA, the *Nuclear Energy Act*, the *Nuclear Fuel Waste Act* and the *Nuclear Liability Act* are the centerpieces 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. Other legislation that provides environmental protection and worker protection, such as the *Canadian Environmental Assessment Act*, *Canadian Environmental Protection Act* and the *Canada Labour Code*, complements these acts.

Canada's nuclear policy framework includes these general elements: a nuclear non-proliferation policy; transparent and independent regulation; a radioactive wastes policy framework; a uranium ownership and control policy; support for nuclear research; design and support for CANDU technology; and cooperation with provincial governments and municipal jurisdictions.

Canada is actively involved with a number of organizations including the IAEA, International Nuclear Regulators Association, the CANDU Senior Regulators group, the Organization for Economic Cooperation and Development's Nuclear Energy Agency (NEA) and the G8's Nuclear Safety and Security Group. These groups afford Canada the opportunity to coordinate activities at the international level, to influence and enhance nuclear safety from a regulatory perspective, and to exchange information and experience among regulatory organizations. Canada is also a participant in the International Framework for Nuclear Energy Cooperation, the Multinational Design Evaluation Program (MDEP; see Article 18), and the Generation IV International Forum and has established a national Generation IV program (see Appendix E for additional details on the Generation IV program).

Canada is a signatory to three other multilateral conventions on nuclear safety:

- The *Joint Convention of the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*
- The *International Convention on the Physical Protection of Nuclear Materials*
- The *International Convention for the Suppression of Acts of Nuclear Terrorism*.

## ***D. Nuclear Power Industry and Recent Major Activities***

### **D.1 Nuclear Power Industry in Canada**

Of the 22 nuclear reactor units in Canada, 17 are currently producing power. During the reporting period, three reactor units were under refurbishment and two units progressed toward a safe storage state. The operation of these reactors is governed by operating licences for seven distinct sites.

The Canadian NPPs are operated by four licensees:

- Ontario Power Generation Inc. (OPG), a private 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 Québec

- New Brunswick Power Nuclear Corporation (NBPN), a crown corporation of the Province of New Brunswick

The licensed sites, licensees, and number of reactors at each are summarized in the following table.

Licensed NPP Site	Province	Licensee	# of Reactors
Bruce A	Ontario	Bruce Power	4
Bruce B	Ontario	Bruce Power	4
Darlington	Ontario	OPG	4
Gentilly-2	Québec	Hydro-Québec	1
Pickering A	Ontario	OPG	4
Pickering B	Ontario	OPG	4
Point Lepreau	New Brunswick	NBPN	1

Appendix B provides basic information on all the units at the NPPs.

The NPPs in Canada use pressurized heavy water reactors of the CANDU design. A full description of CANDU reactors was provided in the first and second Canadian reports. The CANDU design was developed by Atomic Energy of Canada Limited (AECL), which is the federal nuclear research and development company. AECL is developing an ACR-1000 reactor and an Enhanced CANDU 600 (EC6) reactor, both evolving from its in-depth knowledge of CANDU structures, systems, components, and materials, as well as the experience and feedback received from owners and operators of CANDU NPPs. Both the ACR-1000 and EC6 reactors feature major improvements in economics, inherent safety characteristics, and performance. AECL is pursuing opportunities to build an ACR.

All CANDU operators in the world (including NPP licensees in Canada and AECL) are members of the CANDU Owners Group (COG). COG is 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 to all CANDU operators in Canada and internationally.

## D.2 Life Extension of Existing NPPs

Life extension is being pursued or considered for many of the reactor units at the Canadian NPPs. CANDU refurbishment typically involves replacement of major reactor components, such as fuel channels, and the replacement or upgrading of other safety-significant systems. Depending on the circumstances and CNSC approval, a refurbished reactor with replaced fuel channels could operate for approximately 25 or more years. The status of the life extension projects is briefly described below (see subsection 14 (i) c for details.)

### Bruce A Refurbishment

Units 1 and 2 at Bruce A came into service in 1977. Their refurbishment for life extension and continued operation was initiated during the reporting period. Major work items undertaken include:

- replacing reactor components, such as the steam generators, feeder pipes, calandria tubes and fuel channels
- turbine generator overhauls
- replacing feedwater heaters and condenser tubes
- construction of a secondary control area
- electrical distribution system upgrades and maintenance

Unit 2 is the lead unit, with a planned return to service in 2011. Unit 1 is scheduled to return to service four months after Unit 2. During the reporting period, CNSC renewed the operating licence for Bruce A, which included provisions for the refueling and restart of Units 1 and 2.

Bruce Power has not yet committed to the refurbishment of Units 3 and 4. However, if this were to proceed, the Unit 3 refurbishment would likely occur shortly after the return-to-service of Unit 1, followed by Unit 4.

#### Pickering A Return to Service

Pickering A came into service in 1971. In 1997, all four of its units were placed in a guaranteed shutdown state (GSS), in order to focus resources and investment on operational improvements at other NPPs in Ontario. OPG assessed possible refurbishment and return-to-service (see previous Canadian reports for a description of the technical issues involved). Following a detailed environmental assessment (EA) and extensive upgrades, Unit 4 was returned to service in 2003, and Unit 1 was returned to service in 2005.

In 2005, OPG decided not to return Units 2 and 3 to service. The decision was based on the business case, and not on safety concerns or insurmountable technical challenges. OPG determined that the material condition of Units 2 and 3 was inferior to that of Units 1 and 4. For example, the steam generators in Units 2 and 3 were in much worse condition than those in Units 1 and 4. Additional monitoring and inspection of these steam generators and other components meant that OPG would be facing longer outage times in the years ahead. These units are being placed in a safe storage condition, in which the fuel and heavy water has been removed from the reactors, and they will be isolated from containment in the next reporting period. Some Unit 2 and 3 systems will remain energized, providing common system support to the operation of Units 1 and 4. Units 2 and 3 will be maintained in a safe storage state until the entire NPP is shut down for eventual decommissioning.

#### Anticipated Shutdown of Pickering B

Pickering B came into service in 1983 and could continue to safely operate for almost another decade before requiring refurbishment. A refurbishment study was undertaken for Pickering B, but it has been decided not to refurbish the Pickering B units. The capacity and their location were important factors in this decision. At the end of their predicted service lives, the units will be shut down. In the meantime, they will continue to operate as long as the fitness for service requirements are met. In March 2010, OPG submitted a letter to the CNSC with an overview of plans for the maintenance of the Pickering B units to end of life.

### Refurbishment of Darlington

The four reactors at Darlington came into service from the late 1980s to the early 1990s. During the reporting period, a refurbishment study was undertaken to specify the refurbishment scope. It is expected that, once all CNSC approvals are obtained, the refurbishment of the four units could start in the period from 2015 to 2017. The units could be refurbished one at a time, and all would be expected to return to service by 2025.

### Refurbishment of Gentilly-2

In August 2008, Hydro-Québec announced that it intended to refurbish Gentilly-2, which came into service in 1983. Following several technical, economic, and safety studies, Hydro-Québec determined that it was preferable, for economic and environmental reasons, to refurbish the existing installation rather than shutting it down.

The project will consist of two major elements: the complete refurbishment of Gentilly-2 and the construction of a nuclear waste management facility for the onsite storage of solid nuclear waste. These projects will extend the useful life of the NPP up to the 2040 timeframe.

### Point Lepreau Refurbishment

Point Lepreau came into service in 1982. The refurbishment outage started in March 2008. During the reporting period, the following major retube activities were completed.

- The reactor was shut down, defueled, and the systems were placed in a lay-up state.
- All inlet and outlet feeder pipes and fuel channels were removed, and the retube waste was transported to, and stored in, the onsite Radioactive Waste Management Facility.
- Various inspections and cleaning were completed, and calandria tube installation began.
- Upper feeders were installed.

## **D.3 New-Build**

As described in the Fourth Canadian Report, in 2006 both Bruce Power and OPG submitted applications for licences to prepare sites for the future construction of NPPs. Bruce Power's application identified a site within the existing boundary of the Bruce site, while OPG's application identified a site within the existing boundary of the Darlington site.

During the reporting period, Bruce Power submitted two additional applications for a second site located in Ontario and a site in the province of Alberta.

Bruce Power subsequently withdrew all three applications in 2009. The withdrawal of the Ontario applications was based on business considerations, while in the case of the Alberta site, the application was withdrawn pending the outcome of an evaluation of an alternative site in the province.

The OPG application for a licence to prepare site is still current. The project aims to site up to four new nuclear reactors (maximum of 4,800 megawatts of electrical output) directly east of the existing Darlington site, in the municipality of Clarington, Ontario.

A Joint Review Panel was appointed to conduct the environmental assessment (EA). OPG submitted their Environmental Impact Statement (EIS) in support of the EA, as well as the remaining licensing submissions in support of the application for a licence to prepare site. More details on this application are provided in Article 17.



## Chapter II – Summary

### ***Statement of Compliance with Articles of the Convention***

Article 5 of the Convention requires each signatory country 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 a regulator and NPP licensees that focus on the health and safety of persons and the protection of the environment.

### ***General Conclusions***

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 against the regulatory framework and monitor their safety performance of the NPPs. The Canadian NPP licensees fulfill their responsibility to safety, and give it the highest priority at all levels of their organizations. Many provisions are in place and 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, and strive to continuously improve.

The CNSC has continued to update its regulatory framework and align it with international standards (as a minimum). These changes have been introduced into the regulatory framework in a risk-informed way. Amendments and renewals of operating licences for NPPs have been used to introduce new standards and requirements, with provisions for implementation of the new requirements over pre-defined time periods. Typically, the Canadian approach to the setting of requirements is non-prescriptive; that is, the CNSC sets general performance-based regulatory requirements, and NPP licensees develop specific provisions to meet the requirements. Provisions that are critical to safety are approved by the CNSC before licensed activity can begin.

During the reporting period, the CNSC made significant progress in developing the regulatory framework for two key areas — refurbishment and new-build. The CNSC developed many staff review procedures, to assist with the assessment of submissions related to refurbishment projects and new-build licence applications.

In anticipation of increasing activity related to new-build projects, the CNSC also began developing the compliance program required to oversee the various new-build licensing stages,

optimized its employment levels, and began identifying organizational requirements, staffing complements and skill sets for inspectors to implement the compliance program. The CNSC also engaged in the Major Projects Management Office, continued to participate in the Multinational Design Evaluation Program (MDEP), and also conducted vendor pre-project design reviews related to AECL and Westinghouse reactor designs.

Three other regulatory initiatives — licensing basis definition, reformed licence, and licence condition handbook — have helped the CNSC improve the clarity of requirements and expectations for current NPP licensees, and have also facilitated increased regulatory efficiency and effectiveness.

A full scope Integrated Regulatory Review Service (IRRS) mission to Canada was completed in June 2009. The final report included the following statement:

*“The IRRS Review Team was impressed by the extensive preparation at all CNSC staff levels. Throughout the review, the team was extended full cooperation in technical regulatory and policy discussions with CNSC management and staff. The IRRS Review Team identified a number of good practices and made recommendations and suggestions that indicate where improvements are necessary or desirable to continue improving the effectiveness of regulatory controls.*

*These recommendations and suggestions are made to an organization that is seeking to improve its performance and many of them are related to areas in which the CNSC has already or is in the process of implementing a programme for change.”*

The mission report provided a comprehensive summary of the IRRS assessment, and identified 19 good practices, 14 recommendations and 18 suggestions, which provided excellent feedback to the CNSC and its ongoing improvement initiatives.

During the reporting period, the CNSC developed the Harmonized Plan to integrate and align all cross-functional improvement initiatives at the CNSC into a single prioritized plan with clear deliverables. The IRRS mission report identified the Harmonized Plan as a good practice:

*“the consistent Harmonized Plan ... brings together all improvement initiatives under one plan and prioritizes them to optimize use of resources to deliver further improvements in key areas.”*

The objectives of the Harmonized Plan include the delivery of timely and sustainable improvements in CNSC processes, training and tools aligned with shared high-priority issues, and the maximization of horizontal collaboration and partnering across the CNSC. The Harmonized Plan will help the CNSC become a more process-based organization.

Canada has a mature nuclear industry, with an excellent safety record that spans several decades. Any safety issues that arise are addressed by licensees, in order to keep the risk at their NPPs at reasonable levels. Canadian NPP licensees also collaborate on many projects to address safety issues and share information.

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. All events were assessed

as level “0” or “1” on the International Nuclear Event Scale (INES). 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 all the NPPs were kept at approximately 1% of the derived release limits (defined in subsection 15 c). The licensees’ safety analyses, as described in the safety analysis reports, demonstrated acceptable safety margins for all Canadian NPPs. The level of defence-in-depth also remained acceptable during the reporting period for all operating NPPs.

CNSC ratings of NPP safety performance under the CNSC safety areas confirmed that CNSC requirements and performance expectations in all safety areas were met or exceeded at all NPPs for all three years of the reporting period, with only a very small number of exceptions. In those few safety areas where CNSC expectations were not met, the licenses implemented corrective action plans. At the end of the reporting period, CNSC requirements and performance expectations in all safety areas were met or exceeded at all NPPs. The integrated plant ratings, which were generated by the CNSC for the NPPs for the first time in 2008, were either Fully Satisfactory or Satisfactory for all NPPs in both 2008 and 2009.

NPP life extension projects in Canada are being undertaken, in the context of the updated regulatory framework, to extend the safe operating lives of NPPs well beyond their initial design lives. Condition assessments, integrated safety reviews (ISR), and integrated implementation plans are part of a systematic approach to not only maintain the level of safety of the refurbished NPP but to improve it relative to the pre-refurbished condition. See below for a discussion of life-extension activities under Challenge C-1 from the Fourth Review Meeting.

Other major developments in Canada during the reporting period related to nuclear safety are also discussed in the next sections. Some of them are discussed in the context of other challenges assigned to Canada at the Fourth Review Meeting.

### ***Addressing the Challenges for Canada from the Fourth Review Meeting***

Seven specific challenges for Canada were identified at the Fourth Review Meeting. The following describes the highlights of activities during the reporting period to address those challenges.

#### **Challenge C-1: Continue the Refurbishment Activities**

During the reporting period, Canada continued the refurbishment activities and proceeded with preparations, life extension projects, and regulatory oversight. The CNSC document *Life Extension of Nuclear Power Plants* (RD-360) was issued to describe the regulatory framework for refurbishment projects. CNSC staff review procedures were also prepared, to help CNSC staff effectively review all licensee submissions. See subsection 7.2 (i) b, and subsection 14 (i) c for more details. The licensees undertook extensive refurbishment activities at Bruce A Units 1

and 2, and at Point Lepreau. Many safety improvements are being implemented during the refurbishments. See section D.2 of Chapter I and subsection 14 (i) c for more details.

#### Challenge C-2: Reassure the Environmental Qualification of Safety and Safety-related Systems

During the reporting period, several programs evolved at the Canadian NPPs to sustain and update, as necessary, the environmental qualification of safety and safety-related systems. These programs typically involve a governance mechanism, a list of equipment to be maintained in an environmentally qualified state, staff training, technical basis documents, and processes for emerging issues to ensure technical issues related to environmental qualification are managed in a timely way. See subsection 14 (ii) c for more details.

#### Challenge C-3: Plan and Implement Severe Accident Management Guidelines (SAMG) and Plan and Conduct Validation Exercises

During the reporting period, the licensees continued to make progress on the implementation of SAMG and the conduct of validation exercises. The licensees issued SAMG-related procedures and implementing documents, developed and began conducting training for operations and emergency response staff, and began validation exercises in preparation for integrating SAMG into emergency preparedness programs. See subsection 19 (iv) for more details.

#### Challenge C-4: Establish and Pursue a Success Path for Large-break Loss of Coolant Accident (LBLOCA) Safety Margin

Issues associated with safety margins for large-break loss of coolant accidents (LBLOCA) are being systematically resolved as part of the overall work to resolve CANDU safety issues. A risk-informed decision making process was used during the reporting period, as a way to risk-rank safety issues relevant to CANDU reactors and identify potential risk control measures. LBLOCA was included in the comprehensive list of issues that were examined. Five distinct issues related to LBLOCA were subsequently included in the group of Category 3 issues. Category 3 issues are concerns in Canada; they represent situations in which measures are in place to maintain safety margins, but the adequacy of these measures need to be confirmed. Based on the assessment, a preferred set of risk control measures (based on a composite analytical approach) is being systematically pursued to resolve the LBLOCA-related issues. A back-up option (design change strategy) is being developed in parallel, in the event that the preferred option does not meet the pre-defined success criteria. See subsection G.2 in Appendix G for more details.

#### Challenge C-5: Continue Discussions on Possible Implementation of Periodic Safety Review (PSR)

During the reporting period, CNSC staff, in consultation with NPP licensees, continued to evaluate the implications of formally incorporating PSR in the Canadian regulatory process for NPP licensing. It was concluded that adopting the IAEA PSR methodology would result in some benefits with respect to regulatory oversight of NPPs. Several key initiatives were completed during the reporting period; these will facilitate the implementation of PSR if the decision is made to proceed, and include the definition of the licensing basis, improvements to the structure of the operating licence, increased use of risk-informed decision making, and the development and maturation of licensees' management systems. A decision related to the use of PSR must consider factors such as the frequency of public access to the licensing process, the effectiveness

and efficiency of the proposed changes, and the additional burden that may be imposed on the CNSC and the licensees. It is expected that the Commission Tribunal will deliberate the possible application of PSR in Canada in the next reporting period. See subsection 14 (i) d for more details.

#### Challenge C-6: Implement More Fully the Risk-informed Decision Making Process

The risk-informed decision making process was revised and enhanced during the reporting period. The process is being used increasingly for a variety of regulatory decisions and situations, and is now referenced in the CNSC *Management System Manual*. An increasing number of CNSC staff is getting experience in its application, and the nuclear power industry is also becoming familiar with it and endorsing its use. See subsection 8.1 d for more details.

#### Challenge C-7: Plan for an IRRS Mission with Expanded Scope

In 2007, the CNSC expanded the scope of the requested IRRS mission beyond NPPs to cover all facilities and activities licensed by the CNSC, with the exception of import/export licences. A full scope IRRS mission to Canada was conducted in June 2009. The planning for a follow-up self-assessment and IRRS peer review has begun. See General Conclusions above, and Article 8, for more details.

### ***Summary of Other Safety Improvements during the Review Period***

In addition to addressing the seven challenges from the Fourth Review Meeting, numerous other safety improvements were made at the Canadian NPPs during the reporting period. The following are examples of some material improvements to safety at the NPPs:

- retube activities at Bruce Units 1 and 2 and Point Lepreau, to replace key reactor pressure-retaining components (see subsection 14 (i) c for details)
- installation of passive autocatalytic recombiners at Bruce Units 1 and 2 and Point Lepreau, to address hydrogen accumulation inside the containment structure during accident conditions (see subsection 18 (i) and Annex 14 (i) c for details)
- installation and commissioning of the emergency filtered ventilation system at Point Lepreau (see Annex 14 (i) c for details)
- restoration of the functionality of the inter-station transfer bus at Pickering A, which provides power from Pickering B in the event of a main steam line break in the Pickering A power house (see Appendix D for details)
- installation of the auxiliary power system at Pickering, to address issues stemming from the loss of the electricity grid (blackout) on August 14, 2003 (see subsection 19 (iv) for details)
- environmental qualification upgrades at Pickering and Darlington, including improved steam protection provisions (see subsection 14 (ii) c for details)
- fire protection upgrades, such as upgrades to transformer deluge systems, turbine sprinkler upgrades and cable tray fire barrier installations at Bruce A and B (see subsection 18 (i) for details) and fire system improvements related to detection, suppression and egress at Point Lepreau (see Annex 14 (i) c for details)
- installation of a dedicated high efficiency particulate arrestor (HEPA) filter for the main control room at Point Lepreau, to extend habitability during accident conditions (see Annex 14 (i) c for details)

- addition of shutdown system trip parameters at Point Lepreau and adjustment of some trip set points to improve shutdown system trip coverage (see Annex 14 (i) c for details)

Various other safety improvements related to operation, maintenance, inspection and testing are described in subsection 19 (iii).

### ***Summary of Planned Activities to Improve Safety***

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

- continuation of improvements being undertaken in the refurbishment of Bruce Units 1 and 2, and Point Lepreau
- life extension of other, currently operating NPPs (such as Gentilly-2; improvements will include retubing, replacement of control computers etc.)
- installation of passive autocatalytic recombiners at Bruce Units 3 to 8, and also at Pickering A and Darlington (see subsection 18 (i) for details)
- implementation by the licensees of the requirements in CNSC document *Safety Analysis for Nuclear Power Plants* (RD-310; see subsection 7.2 (i) c and subsection 14 (i) a for details)
- fire protection upgrades at Bruce A and B and other NPPs
- completion of initiatives related to environmental qualification of equipment

## **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 22 nuclear power reactors in Canada; all are of the CANDU design. They are situated at seven NPP sites, each with its own operating licence issued by the CNSC. Appendix B provides basic information on all the units at the Canadian NPPs.

### **6 b Justification of continued operation of Canadian NPPs**

#### General Safety Framework and Arrangements

Activities related to NPPs in Canada are governed by robust, modern legislation, with appropriate and well-defined powers to ensure that the NPPs remain safe. The key legislation is the *Nuclear Safety and Control Act* (NSCA). The legislation is complemented by a system of regulations and other elements of the regulatory framework, as described in Article 7. The regulatory compliance program provides comprehensive assessments of the safety performance of the operating NPPs against the regulatory framework, and helps ensure that all reasonable provisions are made to maintain the risk of 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 responsibility to safety, and give it high priority at all levels of their organizations. The remaining Articles in this report describe the many provisions that are in place and 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, and strive to continuously improve. This is evidenced by a willingness to engage in third-party evaluations, such as by the IAEA's Integrated Regulatory Review Services (IRRS) and the World Association of Nuclear Operators (WANO).

The above arrangements are strengthened by the involvement of third-party expertise and participation in international fora and activities, such as the development of IAEA standards. The CNSC continues to update its regulatory framework and align it with international standards (as a minimum). Details are provided in Article 7.

The safety of all existing NPPs in Canada was fully reviewed at the times of their initial licensing. Both the licensees and the regulator have continued to conduct broad and updated

assessments since then (e.g., updates to the safety analysis report, probabilistic safety assessments, and licence renewal assessments). During the reporting period, the licensees' safety analyses, as described in the safety analysis reports, demonstrated acceptable safety margins for all Canadian NPPs. Safety assessments are also conducted in response to significant events and national and international operating experience. The licensees and the regulator have also conducted many detailed verification activities, in support of ongoing operations. These activities are described in Article 14.

NPP licensees limit the life of critical components (such as CANDU fuel channels) and implement aging management plans, to help ensure ongoing safe operation. Licensees perform thousands of tests of safety and safety-related systems annually, in order to confirm their functionality and availability to meet the safety requirements. See subsection 14 (ii) and subsection 19 (iii) for more information on programs that verify safety on a continual basis.

The CNSC has used operating licence renewals to introduce new requirements for NPPs (see Licence Renewals in subsection 7.2 (ii) d). Upgrades are implemented by the licensees on a continual basis to maintain safety margins and incrementally enhance safety (some examples are provided in subsection 18 (i)).

NPP licensees have conducted integrated safety reviews (ISR), which are similar in scope to periodic safety reviews, as part of the planning for potential refurbishment projects. These exercises have included comprehensive and systematic plant condition assessments and the identification of safety improvements that are reflected in integrated implementation plans. These are robust mechanisms for the safe extension of the operating lives of NPPs. These activities have helped improve the level of safety of refurbished NPPs, as compared to the pre-refurbished condition. Refurbishment activities and ISRs are described in subsection 14 (i) c.

The transparency of the regulatory process in Canada, described in 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.

### Operational Safety Record

Canada has a mature nuclear industry with an excellent safety record that spans 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, and all the events were assessed as level "0" or "1" on the International Nuclear Event Scale (INES). The licensees' efforts to address these events were effective in correcting any deficiencies and preventing recurrence.

During the reporting period, the CNSC did not need to engage in formal enforcement action (requests from the Commission Tribunal, orders, licensing action, or prosecution, as described in subsection 7.2 (iv)) to resolve safety-related issues at Canadian NPPs.

Conclusion

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



## **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 subsection C.2 of Chapter I.

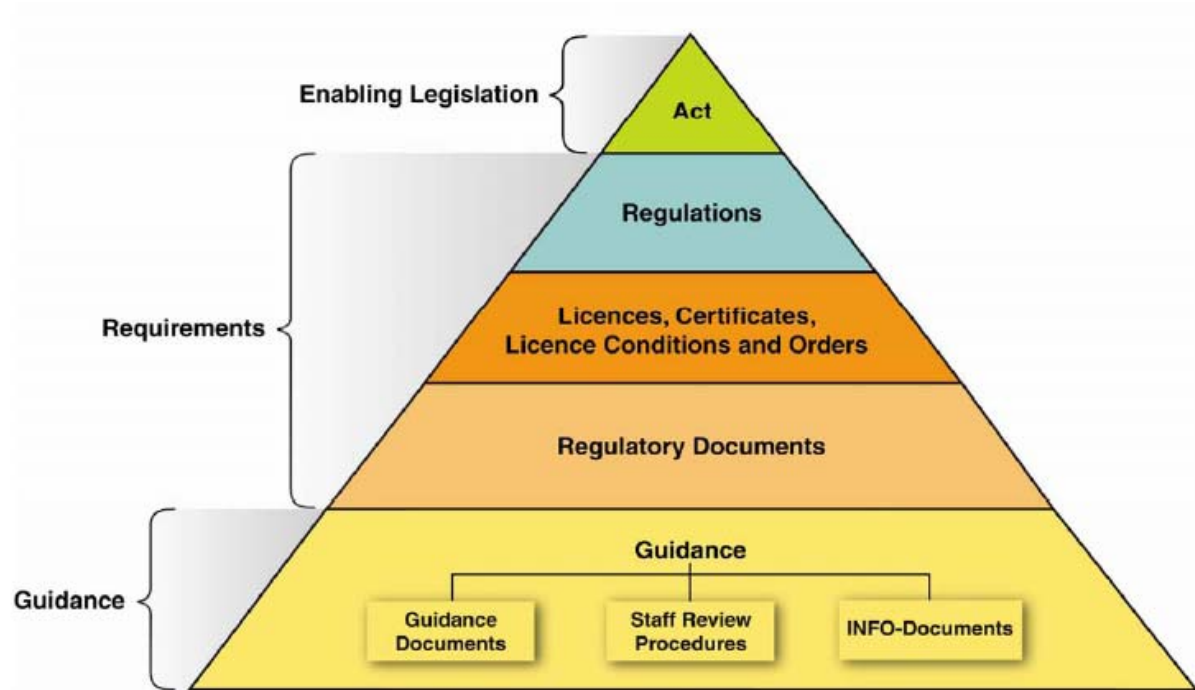
### **7.1 Establishing and Maintaining a Legislative and Regulatory Framework**

The CNSC operates within a modern and robust legislative and regulatory framework. Figure 7.1 depicts the main elements of Canada’s nuclear regulatory framework. This framework consists of laws (acts) passed by the Parliament of Canada, which govern the regulation of Canada’s nuclear industry, and instruments such as regulations, licences 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. Regulatory instruments fall into two broad categories: those that set out requirements, and those that provide guidance on requirements. Requirements are legally binding and mandatory elements, and include the regulations made under the NSCA, licences, and orders. Regulatory documents also become legally binding requirements once they are referenced in licences. The NSCA, regulations, regulatory documents and licences are described in more detail in the sections below.

The IRRS mission report stated, as a particular strength of Canada, that

*“the Canadian legislative and regulatory framework is comprehensive, with an appropriate range of instruments allowing for an effective application of the legal regime.”*

**Figure 7.1: Elements of the Regulatory Framework**

### 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. Under this Act, the Parliament of Canada had declared that works and undertakings constructed for the following purposes were works for the general advantage of Canada, and therefore subject to federal legislative control:

- production, use and application of nuclear energy
- research or investigation with respect to nuclear energy
- production, refinement or treatment of prescribed substances (including deuterium, fissile and radioactive materials)

The *Atomic Energy Control Act* was the legislative basis for regulating nuclear energy and nuclear materials for more than 50 years. However, 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 and environmental protection — updated legislation was required for more explicit and effective nuclear regulation. In response to this requirement, the Canadian Parliament passed the *Nuclear Safety and Control Act* (NSCA) in 1997. The new law came into force on May 31, 2000, and binds Canada's federal and provincial Crowns, as well as the private sector.

Whereas the *Atomic Energy Control Act* encompassed both regulatory and developmental aspects of nuclear activities, the NSCA separates these two functions in law. The NSCA also provided a distinct identity to the new regulatory agency, the Canadian Nuclear Safety Commission (CNSC), which replaced the Atomic Energy Control Board.



The CNSC is comprised of two components: a Commission Tribunal and a staff organization<sup>1</sup>. The Commission Tribunal is a quasi-judicial administrative tribunal that establishes regulatory policy on matters relating to health, safety, security and the environment. It also makes independent licensing decisions and legally binding regulations. The Commission Tribunal is a court of record with powers to hear witnesses, take evidence and control its proceedings, while maintaining the flexibility to hold informal hearings.

Section 9 of the NSCA sets out the CNSC's 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 following:

- the site preparation, design, construction, operation, decommissioning and abandonment of
  - nuclear power plants (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 the following activities:
  - nuclear medicine (such as teletherapy machines and brachytherapy used in cancer treatment, and diagnostic medicine)
  - industry (such as industrial radiography, oil and gas well logging, density gauges)
  - research

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<sup>1</sup> The Canadian Nuclear Safety Commission, or CNSC, refers to the total organization. The tribunal component is referred to as the Commission Tribunal, and the staff component as CNSC staff.

The NSCA enables the regulation of facilities such as NPPs, by establishing a system of licensing, and assigning to the CNSC 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.

The CNSC is also responsible for administering and implementing 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.

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

- clearly defined powers for inspectors, bringing their powers in line with modern legislative practices
- increased penalties for non-compliance, bringing them in line with current practices
- clear appeal provisions for orders of inspectors and officers designated by the Commission Tribunal
- provision for the Commission Tribunal 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 operation, decommissioning and waste management, as a condition of receiving a licence
- recovery of the costs of regulation from entities licensed under the NSCA

### **7.1 b Other legislation, conventions or legal instruments**

Given federal jurisdiction for nuclear regulation, the Government of Canada also regulates some activities that would fall under provincial jurisdiction, were they not associated with nuclear energy. The CNSC is obligated to regulate these areas insofar as they fall under the mandate and scope of facilities and activities specified by the NSCA. This responsibility may be shared with other federal departments or agencies. For example, the CNSC shares the regulation of conventional health and safety for NPPs in Québec and New Brunswick with Human Resources and Social Development Canada, in accordance with Part II of the *Canada Labour Code*. The CNSC also shares the federal regulation of environmental protection with Environment Canada, in accordance with the *Canadian Environmental Protection Act*.

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

- the *Nuclear Energy Act*
- the *Nuclear Liability Act*
- the *Nuclear Fuel Waste Act*
- the *Canadian Environmental Assessment Act*
- the *Fisheries Act*
- the *Species at Risk Act*

- the *Migratory Bird Convention Act*
- the *Canada Water Act*
- the *Navigable Waters Protection Act*
- the *Transport of Dangerous Goods Act*
- the *Emergencies Act*
- the *Emergency Management Act*

Nuclear regulation is clearly under federal jurisdiction. However, under the Canadian constitution, provincial laws may also apply to nuclear regulation in areas that do not relate directly to nuclear energy and that do not conflict with federal law. For example, provincial environmental legislation applies to nuclear facilities. Where both federal and provincial laws may apply, the CNSC tries to avoid duplicative effort by seeking cooperative arrangements with federal and provincial bodies that have regulatory responsibilities or expertise in these areas. Such arrangements are authorized by the NSCA, in order to avoid regulatory overlap. The NSCA also provides authority for the Commission Tribunal and the governor in council (federal cabinet) to incorporate provincial laws and regulations by reference.

## 7.2 Provisions of the Legislative and Regulatory Framework

The nuclear regulatory framework in Canada has, as its basis, a modern and robust legislation. As described in subsection 7.1, the NSCA allows for a supporting and complementary range of regulatory instruments, which includes regulations, licences, and regulatory framework documents.

Good Practice G-1 for Canada from the Fourth Review Meeting  
*“The regulatory process is open and transparent to public including stakeholders”*

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 supporting documents, and the issue of licences (details provided below) provide for the involvement of interested parties and timely communications to stakeholders (additional information on the CNSC’s engagement of stakeholders is provided in subsection 8.2 b). The IRRS mission report stated, as a particular strength of Canada, that

*“the CNSC processes and strategies for third party engagement and in particular for public involvement are comprehensive, open and transparent.”*

During the reporting period, Canada continued its efforts to enhance transparency and engage as many interested stakeholders as possible in the regulatory process.

During the reporting period, the CNSC reviewed the existing set of regulatory instruments. Based on that review, a comprehensive, longer-term plan is being implemented, to further develop and enhance the regulatory framework, in order to meet the ongoing needs of the CNSC and all its stakeholders.

Suggestion S14 from IRRS Mission

*“CNSC should systematically carry out regular periodic review of the published regulations and guides. Then the need for revision of the all regulation and guidance material should be evaluated and on the basis of the evaluation the defined revision steps should be taken.”*

The CNSC recognizes that a systematic, regular review of existing regulations and regulatory documents and guides is essential to ensure that Canada’s nuclear regulatory regime remains up-to-date and reflective of changes in technology and international practices in nuclear regulation, and that it continues to meet the needs of Canadians. The existing regulatory documents, guides and regulations were reviewed in the fall of 2009. During the next reporting period, regulatory documents and guides will be retired or scheduled for review, taking into account corporate priorities and the availability of resources. New regulatory documents and guides to be developed will also be identified, along with new regulations or amendments to existing regulations.

As part of the prioritizing exercise performed during the 2009 review of existing regulatory documents, guides and regulations, it was determined that a five-year business plan for the regulatory framework would allow for more effective long-term planning of resources and better scheduling of projects within the regulatory framework.

## **7.2 (i) National Safety Requirements and Regulations**

### **7.2 (i) a Regulations under the NSCA**

The following regulations are issued under the NSCA:

- *General Nuclear Safety and Control Regulations*
- *Radiation Protection Regulations*
- *Class I Nuclear Facilities Regulations*
- *Class II Nuclear Facilities and Prescribed Equipment Regulations*
- *Nuclear Substances and Radiation Devices Regulations*
- *Packaging and Transport of Nuclear Substances Regulations*
- *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*

The CNSC’s regulatory regime defines NPPs as Class IA nuclear facilities, and the regulatory requirements for these facilities are found in the *CNSC Class I Nuclear Facilities Regulations*.

The *Canadian Nuclear Safety Commission Rules of Procedure* do not impose requirements for health, safety and protection of the environment, but set out rules of procedure for public hearings held by the Commission Tribunal, and for certain proceedings conducted by officers designated by the Commission Tribunal.

Generally, these regulations give licensees flexibility in how they 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.

### Process for Making Regulations

When making or amending regulations the CNSC must abide by the *Cabinet Directive on Streamlining Regulations* — a Government of Canada regulatory policy that came into effect April 1, 2007. This ensures that the potential impact, cost, and level of support of proposed regulations are systematically considered prior to proceeding to make the regulations.

The CNSC 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 their different levels of interest, points of view, and expectations concerning the nature and content of a proposed regulatory regime.

The CNSC regulation making process is described in more detail in Annex 7.2 (i) a.

#### Good Practice G16 from IRRS Mission

*“The Regulation Making Process is very open and transparent with extensive pre-consultations built into the process. Interested parties are consulted already before starting to draft the regulation.”*

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The CNSC shares this practice on a regular basis with other departments and agencies who wish to improve their respective regulation making processes.

### **7.2 (i) b Regulatory framework documents**

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

During the reporting period, it was recognized that the intent and naming conventions of the various documents that have been published, and those currently under development, required clarification. In 2009, the CNSC revised its regulatory framework with the following new categories of regulatory framework documents:

- Regulatory Documents — Provide greater detail than regulations as to what licensees and applicants must achieve in order to meet the CNSC’s regulatory requirements.
- Guidance Documents — Provide practical guidance to licensees and applicants on how they may meet the regulatory requirements of the CNSC.
- INFO-Documents — Plain-language publications describing nuclear-related issues and regulatory requirements and processes, for the general public and other stakeholders. INFO Documents also provide support and further information on other elements of the regulatory framework.
- Staff Review Procedures — Internal working documents used by CNSC staff to assist them in the conduct of regulatory reviews. These documents may be shared with licence applicants, in order to help them structure their applications and provide needed

information (Staff Review Procedures are discussed in more detail in subsection 7.2 (ii) and subsection 8.1 d).

A table listing some of the key CNSC documents that apply to NPPs licensees is provided in Table 7.2 (i) b.1 in Annex 7.2 (i) b.

Suggestion S13 from IRRS Mission

*“CNSC should review and adopt a consistent terminology for its regulatory guides.”*

During the reporting period, the CNSC reviewed and adopted a consistent terminology for all of its regulatory documentation.

Use of Other Standards in the Development of CNSC Documents

As outlined in CNSC regulatory policy *Regulatory Fundamentals* (P-299), the CNSC sets requirements using appropriate industry, national, international or other standards. The CNSC is committed to using other standards, as appropriate, in the effective implementation of its regulatory mandate in Canada. This good practice is in line with the Government of Canada’s April 2007 *Cabinet Directive on Streamlining Regulation*, and is consistent with the CNSC’s vision of regulatory excellence.

The CNSC actively contributes to the development of IAEA safety standards. Several members of the CNSC staff are part of working groups to draft these standards. CNSC representatives also sit on the IAEA’s Commission on Safety Standards and four Safety Standards Committees, with the aim of overseeing the IAEA’s safety standards and advising the IAEA on the overall program on the regulatory aspects of safety.

IAEA standards continue to serve as references and benchmarks for the Canadian approach to nuclear safety, as they have for many years. During the reporting period, the Canadian regulatory framework related to NPPs continued to move towards 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 Canadian technology, practices, and regulatory approach. Table 7.2 (i) b.3 in Annex 7.2 (i) b provides examples of how IAEA standards have been used to develop CNSC documents. Subsection 7.2 (i) c below also describes examples of how CNSC documents related to new-build have been aligned with IAEA documents.

Other international standards, such as the International Organization for Standardization (ISO) 14000 series, are sometimes used in the development of CNSC documents. Alternatively, standards or codes may be referenced directly in a licence. For example, all NPP licences currently reference the National Building Code, the National Fire Code, and the Canadian Standards Association (CSA) standards on NPP quality assurance (QA) programs (N286) and pressure boundaries (N285).

During the reporting period, the nuclear industry, the CNSC, and the CSA 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 voluntary-consensus nuclear standards. Additionally, CNSC management and technical staff are members of the technical committees, subcommittees, and working groups to develop the standards. During the reporting period, the CSA greatly reduced the cycle time to issue standards. Several new standards have been issued and many others have been updated or re-affirmed, as indicated in Table 7.2 (i) b.2 in Annex 7.2 (i) b, which lists CSA standards that are relevant to NPPs.

Good Practice G15 from IRRS Mission

*“Where appropriate the CNSC adopts or adapts national and international standards when developing regulatory requirements. The Canadian government promotes participation in standard setting activities of the IAEA and to the Canadian Standards Association.”*

The CNSC will continue to draw upon national and international standards where appropriate when developing regulatory requirements.

Before incorporating a standard in a licence, the CNSC consults with licensees on the wording of proposed new licence conditions, and discusses the need for a transition period to achieve full compliance. For example, the implementation of the CNSC regulatory standard *Reliability Programs for Nuclear Power Plants* (S-98 rev. 1) involved a series of consultations, such as CNSC-industry workshops and CNSC staff visits to NPPs. Within the current regulatory framework, there are four approaches to incorporate new regulatory standards into existing licences:

- 1) proposal of a new licence condition at licence renewal time
- 2) receipt of a licensee application for a licence amendment
- 3) issuance of an order
- 4) amendment of a licence by the Commission Tribunal, on its own motion.

More information on incorporating standards in operating licences at the time of renewal is provided in subsection 7.2 (ii) d.

Regulatory Documents for Refurbishment Projects

During the reporting period, the CNSC issued the document *Life Extension of Nuclear Power Plants* (RD-360). It states that NPPs should meet modern, high-level safety goals for safe and secure operation throughout their lives. Licensees are expected to adhere to the NSCA and the *Canadian Environmental Assessment Act* (CEA Act), all associated regulations, and their licence conditions, throughout the life extension projects and subsequent reactor operation. In keeping with its regulatory mandate, the CNSC expects licensees to demonstrate that the following objectives are met for any life extension project.

1. The technical scope of the project takes into account the results of an environmental assessment (EA; see subsection 17 (iii) b) and an integrated safety review (ISR; see subsection 14 (i) c) and is adequately reflected in an integrated implementation plan.
2. Programs and processes that take into account the special considerations of the project are established.
3. The project is appropriately planned and executed.

The integrated implementation plan identifies strengths and shortcomings for each of the safety factors identified in the ISR, ranks the shortcomings in terms of safety significance, and prioritizes corrective measures and safety improvements.

One of the actions on Canada from the Third Review Meeting was to develop the regulatory approach for refurbishment and life extension of NPPs. The publication of RD-360 represents a significant step toward that goal. However, it is now recognized by the CNSC and industry that this document should be updated, to include lessons learned from recent refurbishment projects and to align the document with new international regulatory guidance. The CNSC is preparing RD-360 rev. 1, which will broaden the licensees' options for a) the operation of NPPs beyond their original design life and b) the cessation of commercial operations. See subsection 14 (i) c for information on CNSC processes related to refurbishment, including staff review procedures.

### **7.2 (i) c Regulatory framework for new NPPs**

One of the actions on Canada from the Third Review Meeting was to modernize the regulatory framework for licensing new reactor projects. 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 nuclear safety standards, to the extent practicable. These standards set out high-level safety goals and requirements that apply to all reactor designs; that is, they are technology-neutral. Canada has been an active participant in the development of these IAEA standards, as well as the supporting technical documents that provide more specific technical requirements and best practices for the siting, design, construction, operation and decommissioning of new NPPs. These standards and technical documents have served as references and benchmarks for the CNSC's nuclear regulatory requirements for many years.

In 2008, the CNSC revised information document *Licensing Process for New Nuclear Power Plants in Canada* (INFO-0756, rev. 1). The document clarifies the current licensing process in the context of the NSCA, and sets the stage for a series of regulatory framework documents related to the licensing of proposed new NPPs.

The CNSC document *Safety Analysis for Nuclear Power Plants* (RD-310) was issued in 2008. It identifies high-level regulatory information for a NPP licence applicant's preparation and presentation of safety analysis. RD-310 focuses on the high-level requirements for deterministic safety analysis in the evaluation of event consequences. In the next reporting period, the currently operating NPPs will also begin adapting to the approach described in RD-310 (see subsection 14 (i) a, for more details).

The CNSC document *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* (S-294) had been issued in the previous reporting period, and is now incorporated in the operating licences of most of the NPPs. See subsection 14 (i) b for more details.

Also in 2008, the CNSC document *Design of New Nuclear Power Plants* (RD-337) was issued to set out technology-neutral expectations for the design of new water-cooled NPPs. To a large degree, RD-337 represents the CNSC's adoption of the tenets in IAEA document *Safety of*



*Nuclear Plants: Design* (NS-R-1), and the adaptation of those tenets to align with Canadian practices. RD-337 is discussed throughout Article 18.

In addition, the CNSC published *Site Evaluation for New Nuclear Power Plants* (RD-346) in 2008, which articulates CNSC expectations with respect to the evaluation of site suitability over the life of a proposed NPP. RD-346 adapts the tenets of IAEA document *Site Evaluation for Nuclear Installations* (NS-R-3), and 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. More information on RD-346 is provided in the preamble to Article 17.

Several stakeholders have expressed interest in the possible construction of new small reactors. A small reactor is defined as a fission reactor with a thermal power of less than 200 MW (thermal). Small reactors include reactors capable of producing radioactive isotopes, research reactors, steam production units, and small-scale electrical power production units. Regulatory framework activities with respect to small reactors are discussed in more detail in Annex 7.2 (i) c.

## **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 Tribunal. Subsection 24(4) of the NSCA states the following:

*"No licence may be issued, renewed, amended or replaced unless, in the opinion of the Commission, the applicant*

- 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 Tribunal the authority to include in licences any term or condition that it deems necessary for the purposes of the NSCA.

The CNSC's licensing system is administered in cooperation with federal and provincial/territorial government departments and agencies in such areas as health, environment, Aboriginal consultation, transport and labour (see subsection 8.1 a for details). Before the CNSC issues a licence, the concerns and responsibilities of these departments and agencies are taken into account, to ensure that no conflict exists with provisions of the NSCA and its regulations.

The CNSC's regulatory regime defines NPPs as Class IA nuclear facilities, and the regulatory requirements for these facilities are found in the CNSC *Class I Nuclear Facilities Regulations*. These regulations require separate licences for each of the five phases in the life cycle of a Class IA nuclear facility:

- 1) a licence to prepare a site
- 2) a licence to construct

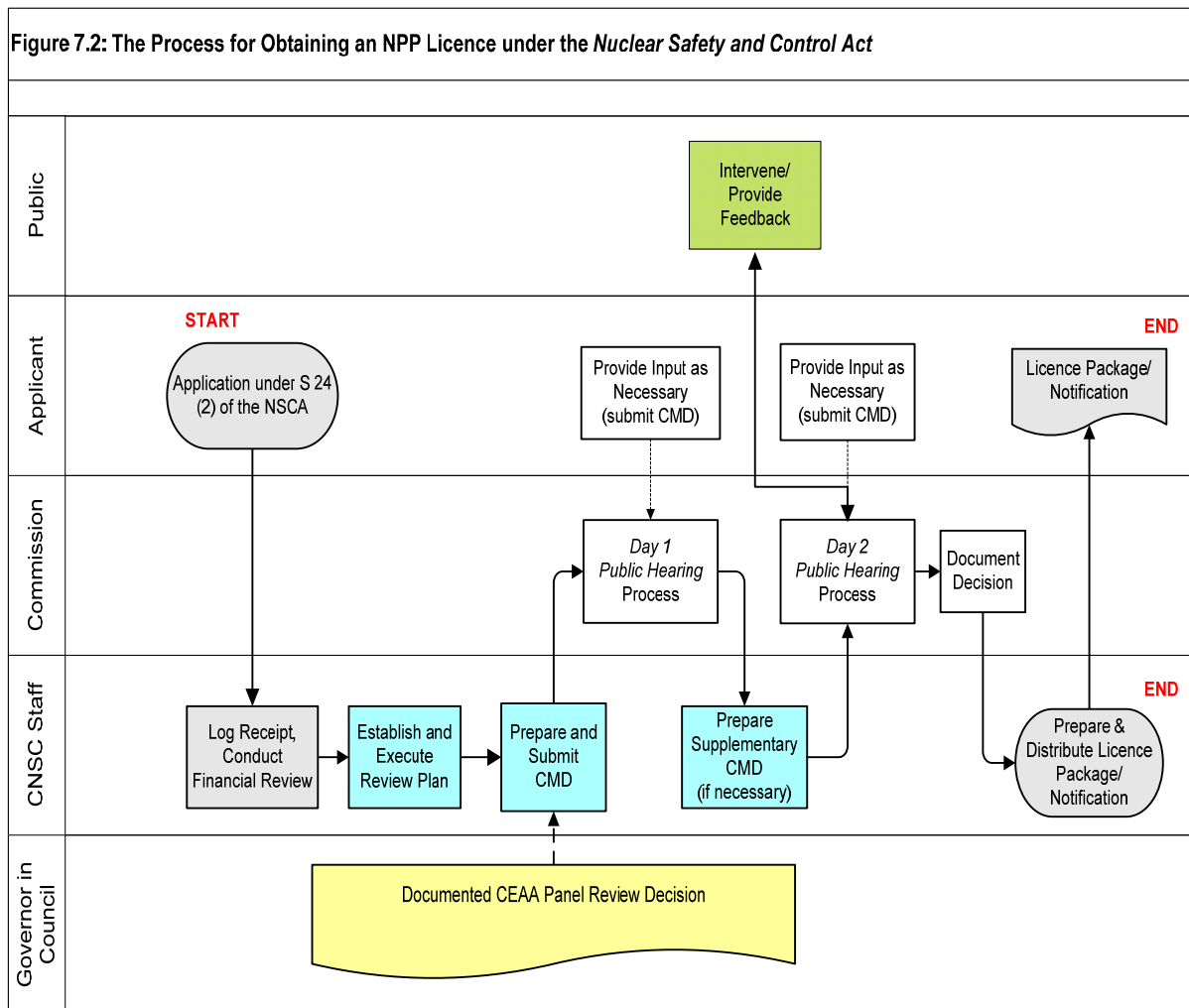
- 3) a licence to operate
- 4) a licence to decommission
- 5) a licence to abandon

The NSCA does not have provisions for combined licences for site preparation, construction, or operation. However, applications to prepare a site, to construct and to operate a new nuclear facility can be assessed in parallel provided the applicant submits supporting information and evidence.

See Articles 17 and 18 for additional details regarding regulatory reviews of new-build projects.

### **7.2 (ii) a Licensing process**

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 Tribunal (identified as ‘Commission’).



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

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

**Bases for Important Requirements for Licence Applications**

Licence Type	General Regulations	Class I Regulations
Licence to Prepare 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

For each licence type, the CNSC is preparing a supporting application guide that provides additional details and criteria (such as national codes and standards, or IAEA safety standards) so the applicant clearly understands what is necessary to satisfy the requirements of the applicable regulations under the NSCA. The application guides related to the licence to prepare site and the licence to construct are expected to be available for public consultation in 2010.

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 that sufficient funds are available to ascertain 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 a plant at the end of its useful 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*.

Subsection 5(1)(d) of the CEA Act stipulates that an EA must be carried out to identify whether a project is likely to cause significant adverse environmental effects before any federal authority issues a permit or licence, grants an approval or takes any other action for the purpose of enabling the project to be carried out in whole or in part. For all new NPPs, the EA is performed before the first licence, namely the licence to prepare site, is issued. An EA addresses all the phases of the project lifecycle (from site preparation through to abandonment). However, as only high-level, preliminary information regarding decommissioning is available when an EA is first carried out, a new EA may be required during the decommissioning phase of the facility. An EA may also be required if the licensee seeks changes to the facility that were not considered in the original EA. The requirement for an EA is revisited before the consideration of all licensing decisions. EAs are described in more detail in subsection 7.2 (ii) b and subsection 17 (ii) a.

#### Definition of Licensing Basis

All the information submitted with a licence application is part of the licensing basis for the NPP. In December 2009, the Commission Tribunal approved the new CNSC definition of the licensing basis, which is now articulated in INFO-0795, *Licensing Basis Objective and Definition*. The licensing basis is 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

The documents needed to support the licence application are those documents that demonstrate that the applicant is qualified to carry out the licensed activity, and that appropriate provisions are in place to protect worker and public health and safety, to protect the environment, and to maintain national security and measures required to implement international obligations to which Canada has agreed.

The licensing basis sets the boundary conditions for acceptable performance at a nuclear facility. Hence, it establishes the basis for the CNSC’s compliance program (see subsection 7.2 (iii)), which is designed to ensure that the licensee continues to meet requirements and conduct the licensed activity within the licensing basis.

#### Licensing Process Documentation

The CNSC employs a risk-informed approach to define the scope of the assessments in its licensing process. Further refinements, along with the formalization and documentation of the common licensing authorization process and criteria, are ongoing, as part of the projects under the CNSC’s coordinated improvement initiative (the Harmonized Plan, which is described in the preamble of Article 8).

The CNSC is executing a comprehensive plan for the preparation of licensing process documentation, regulatory documents and guides, and application guides and forms. This plan includes the integration of knowledge gained from international licensing experience through organizations such as the IAEA, NEA, MDEP, and other national nuclear regulators. The CNSC is also preparing staff review procedures and associated assessment plans to coordinate the internal assessment of applicant submissions. During the reporting period, staff review procedures (see subsection 8.1 d) were completed to coordinate the CNSC’s assessment of submissions related to NPPs, including those pertaining to:

- applications for a licence to prepare a site
- environmental impact statements
- integrated safety reviews for life extension (see subsection 14 (i) c for more information)

Staff review procedures are being developed for the assessment of submissions related to applications for a licence to construct and vendor pre-project design reviews (described in Article 18). During the next reporting period, the CNSC plans to begin preparing staff review procedures for applications for a licence to operate an NPP.

#### Recommendation R3 from IRRS Mission

*“The activities and processes identified within the Harmonized Plan for authorizations in relation to preparation of a comprehensive set of procedures, criteria and review guides should continue to be developed and should be fully implemented.”*

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The CNSC is committed to the implementation of the activities and processes related to authorization (licensing) in the Harmonized Plan. Within the Harmonized Plan, specific improvement initiatives related to authorization are scoped and implemented on a prioritized schedule – this will continue.

Both the EA reviews and the licensing reviews are executed by CNSC staff using an applicant-specific assessment plan within a project management framework. The assessment plan triggers specific reviews, to be conducted by CNSC specialists using topical staff review procedures.

Recommendation R6 from IRRS Mission

*“CNSC should continue and complete its preparation of relevant documentation to support the authorization process (licensing process) for new build.”*

The CNSC has a comprehensive plan for the preparation of licensing process documentation, regulatory documents and guides, application guides and forms, and staff review procedures.

Recognizing the benefits from formalizing and documenting the licensing review process for new-builds, CNSC is extending this approach to all regulated facilities and activities.

Suggestion S15 from IRRS Mission

*“To support knowledge management the CNSC should extend the concept of its internal staff review guides (procedures) to cover all key areas of its function.”*

A key project under the Harmonized Plan is the development and documentation of the processes, procedures and criteria for conducting technical assessments. This will extend the concept of internal staff review procedures to all regulated facilities and activities, and all technical areas.

Assessment of Licence Applications

The CNSC carries out its assessment of an applicant’s supporting information with input from other federal and provincial government departments and agencies that are responsible for regulating health and safety, environmental protection, emergency preparedness, and transportation of dangerous goods.

CNSC staff documents the conclusions and recommendations from its reviews in Commission Member Documents (CMDs) and submits them to the Commission Tribunal. The Commission Tribunal considers the initial conclusions and recommendations at the Day 1 public hearing (refer to Figure 7.2), along with information provided by the licence applicant. At the Day 2 public hearing, the Commission Tribunal, in accordance with the *Canadian Nuclear Safety Commission Rules of Procedure*, invites interventions by other interested parties, who are 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 Day 2 hearing to present their information and engage the Commission. CNSC staff and licensees may also present supplementary or revised information at the Day 2 hearing (e.g., as follow-up to discussion at Day 1).

During and after public hearings, the Commission Tribunal deliberates upon the information provided and makes the final decision on the issuance of the licence. The CNSC issues news releases to inform the public of the decisions made. The records of proceedings from the hearings, and the reasons for the Commission Tribunal’s decisions, are posted on the CNSC Web site.

If the Commission Tribunal decides to issue a licence, any of the information submitted with a licence application that is referenced in the licence becomes a legal requirement for the licensee. Licences may also contain other terms and conditions, such as references to standards, which licensees must meet.

NPP licences typically include control provisions that require the approval of the CNSC, which involve obtaining the Commission Tribunal's permission to proceed for situations or changes where the licensee would be:

- not compliant with a regulatory requirements set out in applicable laws and regulations, or
- not compliant with a licence condition, or
- moving in a direction that is not necessarily safer but for which the objective of the licensing basis is still being met

An example of an approval (for a guaranteed shutdown state based on shutdown system rods) is provided in Appendix H.

Good Practice G4 from IRRS Mission

*“The Canadian regulatory framework provides for a comprehensive and robust authorization system, and processes are in place for authorizing/licensing for all facilities and activities. There are clearly documented authorities and responsibilities either through the commission or delegated to appropriate CNSC staff, e.g. designated officers.”*

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As part of normal regulatory practice, the CNSC continues to seek opportunities for improvement in maintaining a robust authorization system and clear processes.

## 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 a regulated activity in Canada and 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 federal government, under the Ministry of Natural Resources, assumes the role of proponent if it directly sponsors a federal (government-run) NPP project. In either event, the CNSC is not involved in the site selection process.

When applying for a licence to prepare 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 an unreasonable risk 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 site are expected to consider the entire lifecycle of the proposed facility.

In addition, the applicant must also demonstrate that the proposed licensed activity meets all applicable regulatory requirements.

CNSC document *Site Evaluation for New Nuclear Power Plants* (RD-346) describes the general process for evaluating an NPP site in Canada. RD-346:

- provides site evaluation criteria (e.g., to address the effect 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 and public and Aboriginal consultation

Additional information on the site evaluation criteria in RD-0346 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. The information needed to complete this as part of the application for a licence to prepare site will be provided in a CNSC guidance document, currently under development. The guidance document will include criteria for the level of facility design information needed to support the credibility of the site selection case. This document is intended to supplement the related requirements contained in the regulations under the NSCA.

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 the applicant holding public information meetings where the public can express its views and question the applicant.

The CNSC review process (shown in Figure 7.2 in subsection 7.2 (ii) a) utilizes an assessment plan with defined review stages and timelines. CNSC staff review procedures (described in subsection 7.2 (ii) a and subsection 8.1 d) are used to coordinate the CNSC's review of submissions of environmental impact statements (EIS) and applications for a licence to prepare site for NPPs. Public information meetings, and the discussions that follow, also assist in judging the acceptability of the site. The outcome of these reviews is a series of recommendations to a Joint Review Panel, appointed by the federal government (which also serves as a panel of the Commission Tribunal). Following public hearings, the Joint Review Panel renders a decision regarding the environmental assessment (EA) and subsequently, the application for a licence to prepare a site.

The Commission Tribunal can issue a licence to prepare site in either of the following situations:

- when a positive decision has been made on the EA, as required by subsection 5(1)(d) of the CEA Act, or
- when the governor in council authorizes a project to proceed, even if the decision is negative, where effects can be justified in the circumstances described in section 37 of the CEA Act

More information on EAs is provided in subsection 17 (ii) a.

### **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:

- 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

The CNSC is drafting a document that will provide additional guidance regarding construction licence applications. The development of this document utilized IAEA document *Format and Content of Safety Analysis Reports* (GS-G-4.1).

The applicant must show that there are no major safety issues outstanding at the time the Commission Tribunal considers the application for a licence to construction. In order for the applicant to demonstrate this with confidence, 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 the 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, as gained from existing NPPs in Canada and around the world.

Additional areas of focus for the regulatory review include the following:

- readiness of the applicant to provide adequate management oversight of the project, in particular with regard to manufacturing and construction activities, with a schedule that shows how the organisation will develop that oversight as the project develops
- design and safety analysis assessing whether the proposed design and safety analysis, along with other required information, meet regulatory requirements—design and safety analysis is to be accompanied by supporting experimental results, tests and analysis (this is particularly important for novel design features and where the applicant has proposed alternative approaches)

- independent peer review of the safety assessment, conducted by individuals or groups separate from those carrying out the design, including a clause-by-clause assessment against CNSC document *Design of New Nuclear Power Plants (RD-337)*.
- commissioning program
- general plans, including schedules, for the development of the operating organisation, training, staff certifications and operational procedures—the applicant is expected to demonstrate that due consideration has been given to the preparation of an operating organisation that is ready to commission and operate the facility
- policies, strategies, and provisions employed for radiation protection, emergency preparedness, environmental protection, management of radioactive and hazardous waste, decommissioning and safeguards—detailed information is not needed at this stage, but sufficient information must be provided to show that adequate provisions have been made in the design

The scope of a licence to construct covers all facility construction and Phase A commissioning, which is the commissioning of all structures systems and components done without first fuel in-core. 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.

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 plant construction is consistent with the design, and that the licensee is demonstrating adequate project oversight and meeting quality assurance requirements.

Regulatory oversight activities include, but are not limited to:

- inspections, surveillance, reviews, witnessing of commissioning tests, evaluations of commissioning test results
- inspections at manufacturing facilities
- assessing the effectiveness of applicant's oversight of construction and commissioning activities
- granting approvals pertaining to commissioning hold points

Towards the latter part of construction, regulatory attention turns towards the Phase A commissioning program (without fuel loaded) and associated activities. The purpose is to verify, to the extent practicable, that all the systems, structures and components have been installed correctly and are performing according to the design intent (which includes their response to abnormal plant conditions, as credited in the safety analysis). Details on commissioning activities are provided in subsection 19 (i).

In addition, the licensee's progress with regards to organizational development is considered in preparation for an upcoming application for a licence to operate.

## 7.2 (ii) d Licence to operate

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 is some of the information required in support of the application for a licence to operate:

- a description of the structures, systems and equipment at the NPP, 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—which is commissioning of all facility structure, systems, and components with first fuel in-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
  - maintaining nuclear security.

For a licence to operate a new NPP, the CNSC verifies that any outstanding issues from the construction licensing stage have been resolved, in addition to assessing the information included in the application for the initial licence to operate.

The information needed by the applicant to submit a successful application for a licence to operate will be articulated in a CNSC guidance document, which is expected to begin development in the next reporting period.

The initial operating licence will enable the operator to load nuclear fuel and begin fuel-in commissioning (commissioning phases B, C and D). These commissioning activities complete the overall commissioning program of facility structures, systems and components, to confirm the following:

- The key operational safety characteristics match those used in the safety analyses for the plant design.
- The NPP has been constructed in accordance with the design.
- The systems, structures and components important to safety are functioning reliably.

Commissioning is discussed in more detail in subsection 19 (i).

The initial operating licence is expected to be issued with conditions (hold points) to load nuclear fuel, permit reactor start-up, and allow operation at power in steps up to the design rating of the plant. All relevant commissioning tests must be satisfactorily completed before hold points are relinquished.

### Licence Periods

The CNSC uses flexible licence periods, which enable it to regulate NPPs in a more risk-informed manner, through the adjustment of the licence period to the licensee's performance and findings of compliance-verification activities. During the reporting period, the typical NPP operating licence period was 5 years. The imposition of a shorter licence period by the Commission Tribunal is an option where overall licensee performance is unsatisfactory, or because of other considerations.

To assist CNSC staff in making recommendations on licence periods based on sound and consistent rationale, a set of factors was compiled in CNSC Commission Member Document 02-M12. These factors include: facility-related hazards; presence and effective implementation of the licensee's quality management programs; implementation of an effective compliance program from both the licensee and the CNSC; extent of licensee experience; demonstrated acceptable rating of licensee performance; requirements of the CNSC *Cost Recovery Fees Regulations*; and the facility's planning cycle.

### Licence Amendments

The Commission Tribunal can amend a licence to operate an NPP, e.g., to modify existing licence conditions or add new licensing requirements. Licence amendments can be initiated by the Commission Tribunal, or at the request of the licensee.

### Licence Renewals

For the renewal of a licence to operate, the licensee must indicate any changes in information that was submitted in the previous application. Appendix C provides an example list of program descriptions that accompany an application to renew an NPP operating licence. These become part of the licensing basis of the NPP once an operating licence is granted, as described in subsection 7.2 (ii). The CNSC plans and conducts a balanced assessment of the licensee programs and activities, with priority placed on certain areas based on performance history, risk and expert judgment. The assessment is used to provide the Commission Tribunal with a comprehensive review of the licensee and the facility and to support staff recommendations for any licensing decision, as well as to guide ongoing regulatory activities.

Utilizing this approach, the CNSC staff reviews the application with emphasis on the following elements:

- the performance of the licensee and the station 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

For the renewal of a licence to operate, CNSC staff assesses and rates the licensee's programs and their implementation. The set of safety areas and constituent programs used during the reporting period are listed in Table F.2 in Appendix F. The CNSC is planning to refine the safety areas and programs used for assessing NPPs during the next reporting period, by adopting a set that is common to all facilities licensed by the CNSC.

The CNSC uses a rating system to summarize the assessment of the safety area and programs against CNSC regulatory requirements and performance expectations. The rating system changed during the reporting period; the old and new systems and the mapping between the two are also described in Appendix F.

New standards and requirements are systematically incorporated in each operating licence when it is renewed. (The general process and options to impose requirements in new standards on licensees is described in subsection 7.2 (i) b.) Adaptation to a new standard may require an implementation period and/or plan before the licensee fully satisfies the new requirement. The practice of regularly updating the licences to meet new standards is a feature of the Canadian licensing system that is also common to periodic safety review (PSR). The consideration of PSR in Canada is described in subsection 14 (i) d.

During the reporting period, the licences to operate Bruce A, Bruce B, Darlington, and Pickering B were renewed for five years.

The current operating licence for Point Lepreau encompasses a planned 18-month refurbishment outage, in addition to a post-refurbishment period that will extend to the end of June 2011. When the licence to operate was renewed, in June 2006, it was amended to include a number of hold points. These included Commission approval following refurbishment for reloading fuel, restarting the reactor, and for each staged increase in reactor power during commissioning tests. These hold points are expected to be exercised during the next reporting period.

#### Licence Improvement Project

The Licence Improvement Project for Class I facilities was initiated in 2008, under the Harmonized Plan. Class I facilities, as defined in the regulations, include NPPs and research reactors (Class IA facilities) as well as Class IB facilities such as fuel fabrication facilities. The purpose of the project was to develop an improved operating licence format and content for Class I facilities on the basis of:

- requirements set out in the NSCA, *General Nuclear Safety and Control Regulations*, and *Class I Nuclear Facilities Regulations*
- documented CNSC expectations
- national and international regulatory practices and standards, including work by other federal and provincial agencies in areas such as conventional health and safety and pressure boundary (to avoid overlap)
- bases and experience with current licences
- consultations with internal and external stakeholders

The project is anticipated to foster greater consistency of licence formats across CNSC-regulated major facilities, starting with NPPs.

A major result of Phase 1 of the Licence Improvement Project, which concluded during the reporting period, was the renewal of the operating licences for Bruce A and Bruce B in an improved structure and format. Features of the new structure and format are:

- a significant reduction in the number of approval requests submitted by the licensee, as well as in the number of low-risk licence amendments submitted for the Commission Tribunal's approval
- removal of redundant conditions from the licences
- clear, well-defined and streamlined licences following, as far as practicable, the CNSC safety areas
- a reduction in the regulatory burden to the licensee without compromising safety
- more efficient use of regulatory resources
- a process for helping CNSC staff acquire and maintain knowledge of the licensing file

An important aspect of the revised licence structure is the introduction of the licence condition handbook (LCH). 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 to be read in conjunction with the licence.

The LCH associates each licence condition with compliance verification criteria, in order to ensure adequate compliance with the licence, and to provide an explanation for each regulatory requirement specified in the licence by the Commission Tribunal.

The LCH also establishes change control and version control processes for management of records and documents. It documents the graduated enforcement process that would be applied in the event that the CNSC believes the licensee is not in compliance with its licence, starting with the dispute resolution process.

Finally, the LCH documents implementation plans, action items and transition dates for specific licence conditions, and provides, where applicable, the latest revisions and effective dates of CNSC documents, licensee-produced documents and industry codes and standards, as well as criteria for obtaining Commission Tribunal approval or CNSC staff consent.

The first general condition of the renewed operating licences for Bruce A and Bruce B is that the licensee must operate the NPP in accordance with its licensing basis (as defined in subsection 7.2 (ii)). The second general condition is a requirement for the licensee to obtain prior written approval from the Commission Tribunal before deviating from the first requirement in any manner that could adversely affect the safe conduct of the licensed activities. This establishes the essential control of the CNSC on safety-critical matters.

In the new operating licence format for Bruce A and Bruce B, if the licensee proposes to change the version of a particular standard that is cited in the licence, it only needs to be approved by a staff member designated by the Commission Tribunal (the director-general of the Directorate of Power Reactor Regulation). The change would be recorded in the LCH. By comparison, the previous operating licences for Bruce A and Bruce B would require approval, from the Commission Tribunal, of a licence amendment to implement this type of change. By structuring the requirements in this way, the CNSC is making better use of delegated powers to improve efficiency and effectiveness.

The other NPPs in Canada will have their operating licences converted to the new format when they are renewed. Each renewed operating licence will be accompanied by an NPP-specific LCH.

The possibility of longer operating licences would also help the efficiency and effectiveness of CNSC's regulation of NPPs. A licensing system that involves longer licences would have to include sufficiently frequent and meaningful opportunities for public input, and a systematic mechanism to incorporate new standards in the licences, as warranted. Longer licences would be an option if the CNSC decides to pursue the application of PSR to its operating NPPs. The consideration of PSR is described in subsection 14 (i) d.

Recommendation R4 from IRRS Mission

*“CNSC should complete its licence reform project and should document processes and arrangements for Class I nuclear facilities, waste facilities, uranium mines and mills, to ensure that any change or amendment to a licence including the licensing basis does not generate disproportionate amounts of work that would not be commensurate with the potential hazard of the change being proposed.”*

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This is the purpose of the licence reform project for all nuclear facilities and activities in Canada; this project is an in-progress initiative within the Harmonized Plan, and will be completed as planned. Phase 1 concerns NPP licences; the developed approach will then be applied to other nuclear facilities and activities, in a phased approach (Phase 2 – nuclear cycle facilities – model and implementation plan).

Suggestion S5 from IRRS Mission

*“As part of the licence reform project CNSC should consider if alternative approaches with longer term licences and greater use of delegated powers would improve efficiency and effectiveness.”*

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The terms of licences and the use of delegated powers to CNSC staff are being considered within the licence reform project. Any decision regarding changes to licence terms or the use of delegated powers will ultimately lie with the Commission Tribunal. Phase 1 concerns NPP licences; the developed approach will then be applied to other nuclear facilities and activities, in a phased approach (Phase 2 – nuclear cycle facilities), including an assessment of existing staff guidance on licence terms.

### **7.2 (iii) System of Regulatory Inspection and Assessment**

As stated in subsection 7.2 (ii), the Commission tribunal can only issue licences to applicants that are qualified to operate the NPP and that will adequately provide for the health and safety of persons and the protection of the environment.

Section 30 of the NSCA authorizes CNSC staff to carry out inspections in order to verify licensee compliance with regulatory requirements, including any licence conditions. Licensees are expected to have a set of programs and processes in place to adequately protect the

environment, and the health and safety of workers and the public (a representative list of licensee programs is included as Appendix C).

The CNSC regulatory policy *Compliance* (P-211) stipulates that the CNSC takes necessary and reasonable measures to maximize the level of compliance with regulatory requirements of persons regulated by the CNSC. The policy stipulates the design and execution of a compliance program that:

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

The policy is implemented through the corporate-wide compliance process (one of the core processes in the CNSC Management System; see subsection 8.1 d). The compliance process integrates all compliance elements:

- promotion to encourage compliance
- verification activities to confirm that licensees are complying with requirements and expectations
- reactive control measures to enforce compliance (described in subsection 7.2 (iv))

The compliance process provides input to the operating licence renewal process described in subsection 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; as well as dissemination of information to the regulated community about regulatory requirements, and the standards and the rationale behind them. Specific compliance promotion activities include 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. Verification activities include the following:

- 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, including rounds, routine system inspections and surveillance
- desktop reviews, which include reviewing licensee documents such as the station safety analysis reports, event reports etc. (see Annex 7.2 (iii) b for more examples of reports that licensees submit to the CNSC)



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

In general, acceptance criteria that can be used to assess compliance may be derived from one or more of the following:

- legal requirements
- CNSC documents that clarify how the Commission Tribunal intends to apply the legal requirements
- information supplied by licensees to the Commission Tribunal, defining how they intend to meet legal requirements in performing the licensed activity
- CNSC staff's expert judgments, including knowledge of industry best practices

As licences are gradually renewed, in accordance with the format developed through the licence improvement project (see subsection 7.2 (ii) d), LCHs will be established for each NPP, gathering in a single place the acceptance criteria used to confirm compliance with the licensing basis for the NPP. During the reporting period, compliance with the licensing basis for Bruce A and Bruce B was measured against the LCHs that had been prepared for those two NPPs.

### Inspections

Type I inspections are planned to a high degree of detail, with acceptance criteria spelled out in advance. 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 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. The results are recorded in a CNSC report to the licensee, and follow-up actions are documented and assigned target completion dates.

Some Type I inspections are used to evaluate some of the programs listed in Appendix C.

CNSC staff also conducts Type II inspections to assess compliance. A suite of inspection guides is being updated, and additional guides are being developed to support their conduct. The results of Type II inspections are transmitted by letter to the licensee.

While most inspections are planned and scheduled with licensees, inspectors have and do use the power to conduct unscheduled inspections, in reaction to events or other findings.

To help achieve regulatory effectiveness, efficiency, consistency and clarity, the CNSC compliance program uses a planned set of baseline inspections. The baseline set was established by identifying a group of Type I and Type II inspections as well as promotion activities and desktop reviews for a typical plant and operations (e.g., for those programs and areas listed in Appendix C and for the systems and areas listed in Table 7.2 (iii) b.1 in Annex 7.2 (iii) b). Inspections were then assigned to the CNSC safety areas and programs (refer to Appendix F). The baseline set was subsequently refined to represent a reasonable set of inspections for a licensee having acceptable ratings in the safety areas during the preceding period.

The baseline regulatory activities take place over a schedule of five years, the typical licence duration for Canadian NPPs. For safety areas where the licensee does not meet acceptable compliance and safety standards, 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.

Good Practice G11 from IRRS Mission

*“The targeted use of inspections to focus limited regulatory resources on poor performance is an excellent example of optimization of regulatory resources to encourage licensees to improve their regulatory performance.”*

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This is an example of a risk-informed approach to inspection. This practice will continue.

Some improvements to the NPP inspection program are being introduced through the CNSC’s Harmonized Plan. For example, procedures, templates and guides are being produced, to improve the consistency and efficiency of inspections for all Class I facilities.

Recommendation R8 from IRRS Mission

*“CNSC should review and establish coherent and consistent arrangements for the conduct of inspections in Class I Facilities between and within the service lines.”*

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The initiative “Conduct Inspections” within the Harmonized Plan is focused on formalizing procedures, templates and guides aimed at a consistent and coherent approach to inspections (planning and conduct) of all nuclear facilities and activities.

Other, specific initiatives completed during the review period include:

- development and implementation of an inspector training program (see subsection 8.1 c for details)
- revision of the Type I inspection procedures

Event Reporting, Follow-up, Recording and Tracking

The CNSC document *Reporting Requirements for Operating Nuclear Power Plants (S-99)* consolidates and expands upon almost all legislated reporting requirements contained in the NSCA and its associated regulations that apply to NPPs. S-99 is incorporated in the operating licences of all NPPs and includes requirements for scheduled (periodic) and unscheduled (e.g., event) reports. The types of reports required by S-99 are listed in Table 7.2 (iii) b.2 in Annex 7.2 (iii) b.

Preliminary reports for the most safety significant situations or events (as defined in S-99) 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 all events or situations that are outside the normal operations described in the licensing basis. Significance is determined using operational procedures or expert judgement. The urgency with which follow-up to the event should be conducted is also evaluated. The CNSC reviews do not aim to duplicate those assessments already performed by licensees, but rather to ensure that licensees have adequate processes in place to take necessary corrective actions and to incorporate 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. A versatile database (the Central Event Reporting and Tracking System, or CERTS) is used by CNSC staff to record the details of reported events, code, trend, and sort events using various criteria, as well as for tracking licensee and CNSC follow-up.

Good Practice G12 from IRRS Mission

*“The CERTS application developed for event inspection, assessment and corrective action tracking constitutes an efficient tool for event tracking, related inspections and corrective actions.”*

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Noted as a good practice. This CNSC will continue with this practice.

Specific improvement initiatives related to regulatory oversight of events were completed during the review period:

- the development and implementation of licensee event report review procedures
- the development and implementation of CNSC investigation procedures

Situations deemed to be of high 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 Tribunal in a CMD on early notification reports, thus making the information available to all stakeholders. CMD 03-M68 includes guiding criteria to be used by CNSC staff when selecting issues to include.

Performance Indicators

To strengthen the safety review process, the CNSC has developed a set of 17 safety-related performance indicators. CNSC staff uses these performance indicators:

- to benchmark acceptable levels of operational safety
- to allow tracking of operational trends important to safety and, in some cases, performance comparisons across NPPs
- to assess, summarize and report on the performance of licensees with respect to safety
- in the licence renewal process, in annual reviews of NPP performance and in CNSC annual reports on the safety performance of the Canadian nuclear power industry

The performance indicators cover five performance areas of the NPP: operations, maintenance, public safety, worker safety and compliance. Reporting of these indicators to the CNSC is mandatory for all Canadian NPPs, via the references in the operating licences to CNSC document *Reporting Requirements for Operating Nuclear Power Plants (S-99)*.

The CNSC performance indicators are described in Annex 7.2 (iii) b.

### Summation

The CNSC prepares an annual staff report on the safety performance of all Canadian NPPs. The *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants* integrates information gathered through CNSC staff verification activities of the NPPs, and uses the rating system described in Appendix F to summarize the performance assessments of the programs and safety areas for each NPP. The document makes comparisons where possible, shows trends and averages, and highlights significant issues that pertain to the industry at large. It addresses the subject areas evaluated in the licence renewal process and uses CNSC performance indicators to illustrate performance.

One of the actions on Canada from the Third Review Meeting was to improve the rating system used to evaluate licensee performance. During the reporting period, CNSC staff continued to improve the rating system for evaluating NPP licensees and refined its application in the *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants*. Minor changes were made to the definitions of the rating categories. Regarding the application of the rating system, progress was made toward considering all applicable data and achieving objectivity and consistency for the different licensed sites, from one rating period to the next and from one safety area to the next. A risk-informed methodology was used to consider findings from regulatory activities (inspections, document reviews, and event assessments) and reach conclusions about the performance of the safety areas and programs. The findings were systematically combined to generate ratings for each safety area, as well as a single, integrated plant rating for the NPP. Further details on the rating methodology, including the definitions of the rating categories and the calculation of the integrated plant ratings, are provided in Appendix F.

CNSC requirements and performance expectations in all safety areas were met or exceeded at all NPPs for all three years of the reporting period, with only a very small number of exceptions. In those few safety areas where CNSC expectations were not met, the licensees implemented corrective action plans to address any shortcomings. Integrated plant ratings, which were generated for the NPPs for the first time in 2008, were either Fully Satisfactory or Satisfactory for all NPPs, in both 2008 and 2009. Details on the CNSC rating system, and a summary table of the ratings during the reporting period, are provided in Appendix F. The ratings of specific safety areas are cited in this report under specific articles, where relevant.

### **7.2 (iv) Enforcement**

Enforcement includes all activities to compel a licensee into compliance and to deter non-compliance with legal requirements. Enforcement is applied using a graduated approach, where the severity of the enforcement measure depends on the safety significance of the non-compliance and other related factors. If the initial enforcement action does not result in timely compliance, increasingly severe enforcement actions may need to be used. The application of graduated enforcement takes into account such things as:

- the risk significance of the non-compliance with respect to health, safety, national security, the environment and international obligations

- the circumstances that lead to the non-compliance (including acts of willfulness)
- previous compliance record
- operational and legal constraints (e.g., the *Directive on the Health of Canadians*)
- industry-specific strategies

Graduated enforcement tools include the following:

- written notices
- written warnings
- increased regulatory scrutiny
- requests from the Commission Tribunal or an authorized person (as per subsection 12(2) of the *General Nuclear Safety and Control Regulations*) to explain how the licensee plans to address a concern raised by the Commission Tribunal or the authorized person
- orders
- licensing actions (i.e., amendment or suspension of part of a licence, revocation of personnel certification, and revocation or suspension of a licence)
- prosecution

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. 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, licence conditions, codes or standards, but that can compromise safety, national security, or the environment and that may lead to a direct non-compliance, if not corrected. Such non-compliances include:

- a failure to satisfy one of the compliance criteria, if the criteria are 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, licence conditions, codes, standards
- a general or sustained failure to adhere to approved documents, policies, procedures, instructions, programs, or processes that the licensee has established to meet licensing requirements

Examples of licensing activities are as follows:

- **Short-term licence or extension:** If the CNSC is not satisfied that a licensee has the required commitment to safety, as indicated by the current compliance history, CNSC staff may recommend that the Commission Tribunal grant a licence for a shorter term. Alternatively, the Commission Tribunal may grant a short-term extension to allow the licensee sufficient time to make the required improvements before the licence is considered for renewal.

- Licence amendment: CNSC staff may recommend a licence amendment to the Commission Tribunal. The licensee is notified in writing of the proposed action, and is given an opportunity to be heard by the Commission Tribunal. 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 Tribunal on a regular basis, to provide status reports on progress in improvements to operation and maintenance programs
- Licence suspension or revocation: CNSC staff may recommend to the Commission Tribunal 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.

Examples of CNSC actions and licensee responses are included in the description of significant events in Appendix D. For those events, additional regulatory scrutiny (e.g., review of root-cause analysis, inspection, or monitoring) or the issue of recommendations was the only regulatory response required.

A licensee that is subject to enforcement action involving an order or amendment, suspension or revocation of its licence, is entitled to make an appeal to the Commission Tribunal 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 Tribunal. The NSCA gives the Commission Tribunal the authority to make any order without prior notice, where necessary to do so in the interests of health, safety or national security. Where warranted, prosecution is also an option. The following are some examples of specific instances of non-compliance, the severity of which might lead to prosecution:

- 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

In early 2010, the Harmonized Plan issued a document describing the CNSC process to select and apply enforcement tools using a graduated approach. The process provides details on the effective application of the enforcement tools described above, and outlines the responsibilities of CNSC staff and the Commission Tribunal in their execution. The process does not include follow-up and tracking of responses to enforcement action. However, during the reporting period, an action tracking tool was also developed under the Harmonized Plan, in order to track the follow-up to non-compliances and help ensure appropriate and timely responses.

Suggestion S11 from IRRS Mission

*“CNSC should maintain progress in further developing IT tools for action tracking under the Harmonized Plan.”*

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The Harmonized Plan initiative “Action Tracking Tool Part II” is an in-progress initiative designed to address this particular issue. It will be completed as planned.

Generic Action Items (GAI) are follow-up/tracking tools that are specific to NPPs. They are discussed in detail in subsection 14 (i) and subsection G.4 of Appendix G.





## **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.

Canada’s nuclear regulatory body, the CNSC, strives for regulatory excellence. Its vision, as stated in the CNSC’s Management System Manual (described in subsection 8.1 d), is “to be the best nuclear regulator in the world.” This vision is supported by a commitment to continual improvement and peer review.

### IRRS mission to Canada

**Challenge C-7 for Canada from the Fourth Review Meeting**  
*“Plan for an IRRS mission with an expanded scope”*

As stated in the fourth Canadian report, in 2005, the CNSC requested an Integrated Regulatory Review Services (IRRS) mission to Canada. The CNSC’s initial preparation for the mission was a self-assessment that covered three “modules”:

- general requirements
- regulatory activities
- management system

The self-assessment of regulatory activities focused on the regulation of NPPs.

The CNSC endorsed an integrated approach to address the major recommendations and suggestions from the self-assessment, in order to capitalize on existing initiatives and broaden their scopes to reach across the operational part of the CNSC. The corrective action plan comprised improvement initiatives/projects in the following five key areas:

- management system
- integrated planning and performance management
- compliance
- licensing
- leadership development

These were aligned under the Integrated Improvement Initiatives Program, which, among other things, produced detailed CNSC-wide process maps for planning, licensing and compliance.

In the fall of 2007, the CNSC expanded the scope of the mission to include the regulation of nuclear substances, medical and research facilities, waste management facilities, research reactors, and fuel cycle facilities including uranium mines and mills. In 2008, a 'complementary' self-assessment was conducted for the regulatory activities of the Directorate of Nuclear Cycle and Facilities Regulation and the Directorate of Nuclear Substance Regulation. The results of this complementary self-assessment confirmed the direction of the previously identified improvement initiatives, but recommended that they be better coordinated with clearer priorities and shorter-term deliverables.

The need to improve the coordination and strengthen the implementation of important improvement initiatives led to the development of the Harmonized Plan for Improvement Initiatives (referred to herein as the Harmonized Plan), which builds on work initiated under the Integrated Improvement Initiatives Program and incorporates and prioritizes other initiatives (identified in previous assessments and audits) on an ongoing basis. The Harmonized Plan is described in more detail in the next section. The initial version of the Harmonized Plan was considered to be the corrective action plan for the self-assessment and the IRRS peer review.

In 2009, the CNSC combined its initial and complementary self-assessments and updated the answers to the questions. The questionnaire was aligned with the requirements in two IAEA standards: *Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety* (GS-R-1) and *The Management System for Facilities and Activities* (GS-R-3).

The CNSC also identified eight thematic areas (specific facilities, activities or program areas) for a more focused assessment against relevant IAEA standards and guidance and good practices by the IRRS peer review team.

In 2009, a detailed IRRS reference package was prepared and provided to the peer review team in advance of the mission. It included the questionnaire, thematic area write-ups, an assessment of strengths of the CNSC, proposed actions to improve regulatory effectiveness, and other reference information related to the mission.

The scope of the IRRS mission included all activities and facilities licensed by the CNSC, with the exception of import and export licences. All activities and facilities within scope were assessed with respect to the eight IRRS modules.

- Module I Legislative and Governmental Responsibilities
- Module II Responsibilities and Functions of the Regulatory Body
- Module III Organization of the Regulatory Body
- Module IV Authorization
- Module V Review and Assessment
- Module VI Inspection and Enforcement
- Module VII Regulations and Guides
- Module VIII Management System

The thematic areas for the IRRS mission to Canada were the following:

- regulating the operation of nuclear power plants

- regulating the refurbishment of nuclear power plants
- licensing of new nuclear power plants
- regulation of uranium mining
- radiation protection programs
- environmental protection programs
- implementation of IAEA *Code of Conduct on Safety and Security of Radioactive Sources* (2004)
- implementation of IAEA *Code of Conduct on Safety of Research Reactors* (2004)

Three technical areas were identified as out of scope for the IRRS mission to Canada: security, emergency preparedness, and safeguards.

Three policy issues were also addressed during the mission:

- research for safety and regulatory purposes
- roles and responsibilities of technical services in support of regulatory decision-makers
- new-builds: regulatory transition from pre-operational to operational phases

The peer review team consisted of 21 members, representing 13 countries. They completed their review, including a draft mission report, during their visit to the CNSC from June 1 to June 12, 2009. The mission included observations of regulatory activities and a series of interviews and discussions with key CNSC personnel and the staff of other organizations (e.g., staff of the Ministry of Natural Resources (NRCan), Health Canada, and various licensees). During the mission, the team members visited CNSC site offices and more than 10 licensed facilities, including two NPPs – Bruce A and Darlington.

The final report on the mission to Canada was issued in 2009, and is available on the CNSC Web site<sup>2</sup>. It included the following statement in the summary:

*“The IRRS Review Team was impressed by the extensive preparation at all CNSC staff levels. Throughout the review, the team was extended full cooperation in technical regulatory and policy discussions with CNSC management and staff. The IRRS Review Team identified a number of good practices and made recommendations and suggestions that indicate where improvements are necessary or desirable to continue improving the effectiveness of regulatory controls.*

*These recommendations and suggestions are made to an organization that is seeking to improve its performance and many of them are related to areas in which the CNSC has already or is in the process of implementing a programme for change.”*

The mission report provided a comprehensive summary of the IRRS assessment, and identified 19 good practices, 14 recommendations, and 18 suggestions that collectively provided excellent feedback to the CNSC and have helped inform the CNSC’s ongoing improvement initiatives under the direction of the Harmonized Plan. The IRRS good practices, recommendations, and suggestions that are relevant to the regulation of NPPs are cross-referenced in this report

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<sup>2</sup>

[http://www.nuclearsafety.gc.ca/pubs\\_catalogue/uploads/IRRS\\_Canada\\_Final\\_Mission\\_Report\\_and\\_Management\\_Response.pdf](http://www.nuclearsafety.gc.ca/pubs_catalogue/uploads/IRRS_Canada_Final_Mission_Report_and_Management_Response.pdf)

(italicized, in boxes) under the most relevant article, to provide the reader with an independent assessment of some of the provisions for the article. The responses of CNSC management to the good practices, recommendations, and suggestions from the mission report are also indicated in the boxes.

Planning for a follow up self-assessment and IRRS peer review has begun, and will continue during the next reporting period.

#### General Description of the Harmonized Plan and Other Improvement Initiatives

The Harmonized Plan is the corporate, client-driven, improvement plan for the CNSC that integrates and aligns all cross-functional improvement initiatives into a single, prioritized plan with clear deliverables. The Harmonized Plan leverages commonalities between the different improvement initiatives and helps to streamline business processes, prioritize work, and distribute resources to maximize effectiveness and efficiency. It makes planning easier and help managers work together to reduce duplication and redundancy. The Harmonized Plan is refreshed regularly to ensure it remains aligned with corporate priorities. The CNSC's Management Committee provides overall direction and leadership to the Harmonized Plan. The executive authority for the Harmonized Plan is the executive vice-president and chief regulatory operations officer (see subsection 8.1 b).

The objectives of the Harmonized Plan include:

- delivery of timely and sustainable improvements in CNSC processes, training and tools focusing on addressing common or shared high-priority issues and concerns
- advancement of CNSC efforts to become a more process-based organization
- facilitation and maximization of horizontal collaboration and partnering across the CNSC
- strengthening the alignment between improvement initiatives and overarching and organizational priorities

The preparations for, and execution of, the IRRS mission were executed as a project under the Harmonized Plan.

The IRRS mission report stated, as a particular strength of Canada, that

*“the consistent Harmonized Plan that considers the results of all recent audits and assessments brings together all improvement initiatives under one plan and prioritizes them to optimize use of resources to deliver further improvements in key areas.”*

The IRRS mission report also identified the Harmonized Plan as a good practice.

#### Good Practice G17 from IRRS Mission

*“The Harmonized Plan developed by CNSC is an excellent tool for driving improvement initiatives across the organization with clear management commitment and allocation of resources and is supported by a communications strategy.”*

The CNSC will continue to use the Harmonized Plan as a vehicle for improvement initiatives. Additionally, the CNSC is sharing its Harmonized Plan experiences with international regulators who are in the process of managing similar improvement plans.

Many Harmonized Plan improvement initiatives are directly relevant to the regulation of NPPs, and will help improve the effectiveness and efficiency of the power reactor regulatory program. Other, more focused improvements that exist outside the Harmonized Plan, will also help establish a power reactor regulatory program that is risk-informed, cohesive, consistent, systematic, effective and efficient, by:

- establishing levels of regulatory activities that are founded on a formal, well-articulated risk-management approach
- developing, establishing and implementing documented processes and procedures, defining how the many contributors work together in a coordinated and well-managed manner
- improving information management in support of the power reactor regulation program
- ensuring a consistent regulatory approach is applied for all NPP licensees

Improvement initiatives relevant to NPPs are described under the relevant articles of this report.

### **8.1 Establishment of the Regulatory Body**

The CNSC is the nuclear regulatory body in Canada, as established by the NSCA. The fulfillment of its mandate (see subsection 7.1 a) is accomplished by the work of the Commission Tribunal, a quasi-judicial administrative tribunal comprised of a maximum of seven members. Commission Tribunal members are chosen based on their credentials, and are independent of all political, governmental, special interest group or industry influences. The members are appointed by the governor in council (Cabinet) of Canada, for terms not exceeding five years, and may be reappointed. One member of the Commission Tribunal is designated as both the president and the chief executive officer of the CNSC, as an organization.

In keeping with federal policies on public consultation and regulatory fairness, the CNSC consults with, and engages, parties and organizations with an interest in its regulatory activities. These include the following parties:

- CNSC licensees
- the nuclear industry
- federal and provincial departments and agencies, and municipal governments
- Aboriginal groups
- special interest groups
- other groups or individual members of the public

More information on stakeholder engagement is provided in subsection 8.2 b. Additional information on plans to support the level of engagement of Aboriginal groups and the public during the environmental assessment (EA) process is provided in subsection 8.1 a.

To promote openness and transparency, the Commission Tribunal conducts business to the greatest extent possible in public hearings and meetings and, where appropriate, in communities affected by the decision at hand. CNSC public hearings and meetings represent the public's primary opportunity to participate in the regulatory process. CNSC staff attends these hearings, as necessary, to advise, and make recommendations to, the Commission Tribunal.

CNSC staff regularly makes reports at Commission Tribunal public hearings and meetings on NPP status; licensees performance; overall industry performance; mid-term assessments; and findings resulting from licensing and compliance activities. The scope and depth with which each of these areas is covered reflect the complexity and level of risk of the licensed facilities at the time of reporting.

Subsection 17(1) of the NSCA stipulates that the Commission Tribunal can also retain the services of external persons having technical or specialized expertise to advise it, independently of CNSC staff. The Research and Support Program (described in subsection 8.1 d) provides access to independent advice, expertise, experience, information and other resources, via contracts placed in the private sector and with other agencies and organizations in Canada, as well as in other countries.

Suggestion S4 from IRRS Mission

*“The CNSC should consider the use of issue-specific advisory bodies to support regulatory decisions where there are either new, complex technologies (e.g. emerging medical applications) or issues of high public interest.”*

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The CNSC previously maintained standing expert advisory committees, but terminated these to rely instead on its highly qualified technical staff and on ad-hoc expert advisory committees, on an as-required basis. However, the CNSC does recognize the value of using issue-specific advisory bodies to support regulatory decisions in complex or high public interest matters within predetermined timelines. Thus, the CNSC will implement this suggestion in appropriate situations.

### **8.1 a Position and funding of the CNSC within the government structure**

The CNSC is a departmental corporation, listed in Schedules II and V of the *Financial Administration Act*. The NSCA stipulates that the CNSC shall report to the Parliament of Canada through a minister for the purposes of the NSCA, designated by the governor in council (Cabinet). Currently, this designate is the minister of Natural Resources Canada (NRCan).

The Commission Tribunal requires the involvement and support of the minister for special initiatives, such as amendments to regulations and requests for funding. The CNSC’s operations are partially funded through annual appropriations from Parliament, and from fee revenues from its fee-paying licensees. Almost 70% of the costs incurred for CNSC regulatory activities are recovered through these regulatory fees, in accordance with *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations*. Effective 2009–10, the CNSC has been granted the authority to re-spend these revenues to fund its regulatory activities. Fees are not charged for 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 maintaining the NSCA and its associated regulations).

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, or from the Treasury Board Management Reserve, in case of emergency funding requirements. While the CNSC always seeks to increase the efficiency of its operations, the CNSC can also address workload pressures associated with fee-paying licensees through an increase of its regulatory fees.

Suggestion S2 from IRRS Mission

*“CNSC should review its arrangements to ensure that it can adequately recover its regulatory costs.”*

The CNSC recovers its regulatory costs through fees (revenue spending authority) and parliamentary appropriations for fee-exempt activities. The CNSC has assessed and will continue to assess its cost recovery regime, to ensure that appropriate arrangements are in place to adequately finance all regulatory operations.

In performing its activities, the CNSC routinely interacts with other federal departments. For example:

- CNSC staff communicates with management and staff of NRCAN in areas of mutual interest.
- NRCAN formulates the Government of Canada's policy regarding nuclear energy and natural resources; it is also a licensee for the cleanup of certain low-level radioactive wastes on behalf of the Government of Canada and, consequently, is subject to CNSC policies and licensing matters.
- CNSC often works with Foreign Affairs and International Trade Canada, to ensure fulfillment of Canada's international commitments pursuant to bilateral and multilateral treaties, conventions and understandings.

In early 2010, the Government of Canada made plans to improve the regulatory review process for large energy projects, by accommodating the existing 'substitution' provisions of the *Canadian Environmental Assessment Act* (CEA Act). This would enable the delegation of process and decision making for environmental assessments (EA) from the CEA Act to another federal department or jurisdiction under its respective regulatory legislation. Before this can be put in place for large projects related to nuclear energy, the NSCA will have to be amended to allow the CNSC to establish a Participant Funding Program and to support levels of Aboriginal and public engagement consistent with those required under the CEA Act.

In 2007, the CNSC signed a memorandum of understanding for the *Cabinet Directive on Improving the Performance of the Regulatory System for Major Resource Projects*. The Major Projects Management Office was established by the Government of Canada for the purpose of overseeing and tracking federal reviews, as well as Aboriginal engagement and consultation for major resource projects. One of the roles of the Major Projects Management Office is to engage federal stakeholder agencies (including the CNSC) that will be participating in the review process for a new nuclear reactor project to commit those agencies to achieve their deliverables within a common project timeline. These agency commitments are captured in a document

known as a ‘project agreement’, which is unique for each project and ratified by the heads of the participating agencies.

The CNSC also works with several provincial and municipal organizations, as appropriate, in fulfilling its mandate.

CNSC issues NPP operating licences to the nuclear operations of provincially-owned electrical utilities OPG, Hydro-Québec, and NBPN (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:

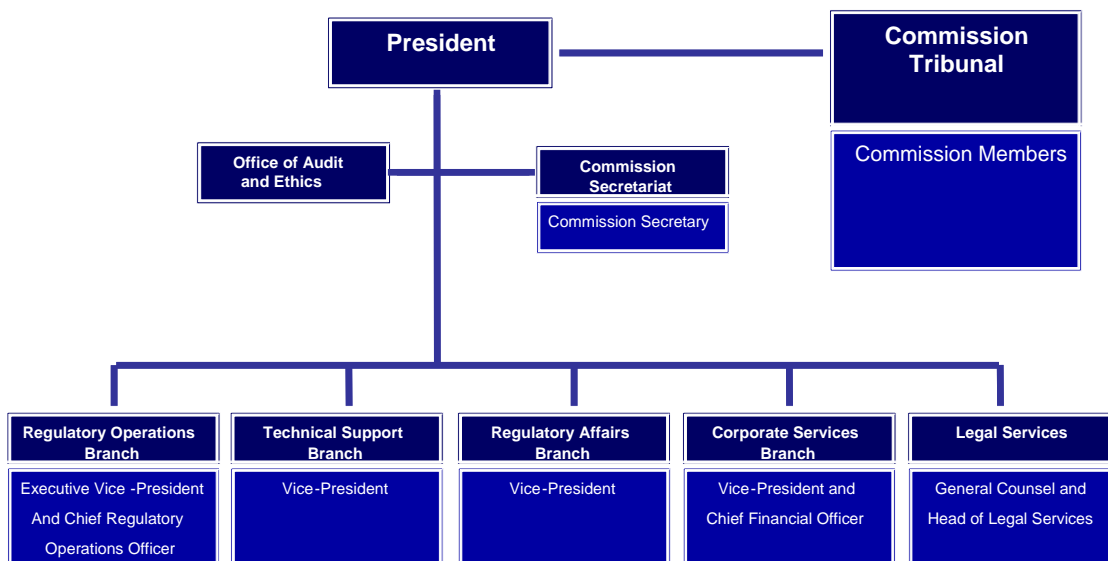
- AECL (the federal nuclear research and development crown corporation)
- NRCan
- Canadian universities
- hospitals and research institutions
- federal and provincial government departments

**8.1 b Organization of CNSC staff**

The CNSC consists of a president, the federally appointed members of the Commission Tribunal, and approximately 850 staff members. Subsection 12(1) of the NSCA states that the president “has supervision over and direction of the work of the members and officers and employees of the Commission,” including professional, scientific, technical and other officers employed for the purpose of carrying on the work of the Commission.

The CNSC’s current organizational structure is described below.

**Figure 8.1 b Organization of the CNSC**



The Office of Audit and Ethics is responsible for independently and objectively assessing the performance of the CNSC in terms of effectiveness and efficiency in relation to its regulatory mandate, and for advising on related improvement initiatives. It also provides guidance, advice



and assistance in the implementation of the CNSC Values and Ethics Strategy (see subsection 8.2 b for additional discussion of ethics). Other groups that support the organization include the Commission Secretariat and Legal Services. The Commission Secretariat organizes all Commission Tribunal hearings and meetings, and provides the seven-member Commission Tribunal with administrative and technical support. Legal Services acts as counsel to the Commission Tribunal in its statutory roles, and provides legal representation in litigation and prosecution cases.

The CNSC has four major branches: Regulatory Operations, Technical Support, Regulatory Affairs and Corporate Services.

### Regulatory Operations Branch

The Regulatory Operations Branch is responsible for managing regulatory activities, as well as licensing and compliance decision making under designated offers and designated authorities. It is headed by the executive vice-president and chief regulatory operations officer, and is comprised of 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 (DPRR) regulates the development and operation of NPPs in Canada, in accordance with the requirements of the NSCA and its associated regulations. In November 2008, the divisions within DPRR were realigned to increase the effectiveness and efficiency of the power reactor regulatory program. The directorate currently consists of the following divisions:

- four regulatory program divisions (for Pickering, Darlington, Gentilly-2/Point Lepreau and Bruce)
- the Compliance Monitoring Division
- the Licensing Support Division
- the Planning and Reporting Division

The Darlington, Pickering, Bruce and Gentilly-2/Point Lepreau regulatory program divisions (RPDs) are accountable for the planning, management and implementation of the power reactor regulatory program at their respective NPPs. Each RPD also acts as a single point of contact for internal and external stakeholders. A communications protocol is in place to govern official and unofficial communications between CNSC staff and the licensees.

Permanently-situated CNSC staff members work at each site to lead and assist in the conduct of the CNSC compliance program activities (described in subsection 7.2 (iii) b). These site inspectors inspect licensee premises, monitor activities and ensure compliance with the licensing basis. As a result of the re-organization in 2008, CNSC site staff members in the former Inspection Division were integrated into their respective RPDs. This has provided the RPDs with greater control over CNSC activities at site and significantly improved CNSC-licensee interfaces, resulting in wider, faster and more efficient information flow between sites and head

office. In addition to the power reactor site inspectors at site, each RPD is also staffed with technical personnel at head office.

Suggestion S12 from IRRS Mission

*“Strategies, processes and methods should be established to ensure the objectivity and independence of the site inspector. Consideration should be given to changing the site to which they are assigned from time to time or giving them general duties at headquarters.”*

The CNSC’s hiring practices and candidate profiles, training on ethics, supervision, management oversight and work practices have been assessed to ensure that they maintain the objectivity and independence of CNSC site inspectors. Assignments, voluntary moves and work terms at other sites and headquarters continue to be encouraged, planned and budgeted for. Inspectors welcome the chance to compare work methods and expectations. Technical support divisions staff based in headquarters, who cover more than one site within their specialty area, look for uniformity in staff regulatory coverage among nuclear generating stations. The CNSC management reviews inspector assignments on a routine basis.

The Compliance Monitoring Division is accountable for discharging the CNSC’s international obligations with respect to the NEA/IAEA Incident Reporting System (see subsection 19 (vi)) and the International Nuclear Event Scale. The Compliance Monitoring Division also ensures consistency in compliance activities across sites, identifies trends in compliance information, manages performance indicator data and conducts event investigations.

The Licensing Support Division is responsible for directorate-wide projects, such as the licence improvement project, safe operating envelope, and the possible conduct of periodic safety reviews (described in subsections 7.2 (ii) d, 19 (ii) b, and 14 (i) d, respectively). The division also manages CANDU safety issues and generic action items (described in subsection 14 (i)).

The Planning and Reporting Division is responsible for planning, monitoring and reporting of DPRR resource utilization and licensee safety performance. The division provides advice and assistance in program and process development, including improvement projects, as well as coordinating DPRR input into various reports.

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

The Directorate of Nuclear Cycle and Facilities Regulation and the Directorate of Nuclear Substance Regulation, also within the Regulatory Operations Branch, also contribute to the regulatory program for NPPs. The Directorate of Nuclear Cycle and Facilities Regulation is responsible, among other things, for waste management facilities associated with NPPs. 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 transport, sealed sources etc).

The Directorate of Regulatory Improvement and Major Projects Management was created in the Regulatory Operations Branch during the reporting period, and 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 the maintenance and updating of the Management System (described in subsection 8.1 d) and the conduct and coordination of the Harmonized Plan. Among the responsibilities of the Regulatory Operations Coordination Division are the operations planning process and the research and support program, also described in subsection 8.1 d.

The New Major Facility Licensing Division is mandated to execute the licensing, compliance, Aboriginal consultation and project management of new major projects and their related regulatory framework improvement projects at the CNSC. The New Major Facility Licensing Division manages pre-project vendor design reviews, to provide vendors with regulatory guidance in regards to their designs (see preamble to Article 18). It also participates in international activities that have a bearing on new-build projects, including those of the Multinational Design Evaluation Program (MDEP; see preamble to Article 18)). This division plays a lead role in the preparations for new-build described in subsection 8.1 e.

#### Technical Support Branch

Staff of the Technical Support Branch provides technical support to the regulatory activities of DPRR. This is accomplished by providing specialist advice for regulatory programs, reviewing NPP licensee submissions, participating in inspections, and helping to develop relevant 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 resolve issues. The staff of the Technical Support Branch also shares scientific and technical information and experience with stakeholders in Canada and in other countries, and undertakes special projects within its expertise and mandate.

The Technical Support Branch is comprised of 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 a wide variety of areas, which include:

- safety analysis, including probabilistic safety assessment and hazards analyses
- design, aging management, mechanical, civil, and material engineering, external events, structural integrity, fire protection, robustness and vulnerability design engineering
- instrumentation and control systems, electrical systems, maintenance, equipment qualification, and chemistry control

- reactor physics, nuclear design, nuclear criticality, nuclear fuel and fuel channel behaviour
- behaviour of the reactor, containment, hydrogen, auxiliary systems, and fission product transport
- thermalhydraulics, reactor system design, and reactor system behaviour

The staff of the Directorate of Assessment and Analysis participates in many compliance activities, including verification of continued fitness-for-service of systems, equipment and structures (assessment of periodic and in-service inspections and lifecycle management programs for pressure retaining systems and components, and structures).

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 Thermalhydraulics Division
- Assessment Integration Division

The Directorate of Safety Management has expertise in the areas of human and organizational safety management, human factors, safety culture, quality assurance/management, examination, certification, and training programs. It consists of four divisions:

- Management Systems Division
- Personnel Certification Division
- Human and Organizational Performance Division
- Training Program Evaluation Division

The Directorate of Environmental and Radiation Protection and Assessment has expertise in the areas of environmental assessment, risk assessment, monitoring, and management systems, as well as radiation protection, dosimetry, and health sciences. It consists of five divisions:

- Environmental Risk Assessment Division
- Environmental Assessment Division
- Environmental Compliance and Laboratory Services Division
- Radiation Protection Division
- Radiation and Health Sciences 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, which relies on close cooperation and planning with other federal agencies, as well as provincial and international organizations. It also has expertise in nuclear security, import/export of nuclear substances, equipment, and devices, non-proliferation, and safeguards. The Directorate of Security and Safeguards consists of five divisions:

- Nuclear Security Division

- Emergency Management Programs Division
- International Safeguards Division
- Safeguards Accounting and Technology Division
- Non-Proliferation and Export Control Division

Suggestion S3 from IRRS Mission

*“Staff from the Regulatory Operations Branch and Technical Support Branch branches of CNSC may wish to review how they could work together in a more harmonized manner to ensure that security measures do not compromise safety and vice versa and to ensure continued compliance with security requirements as reviewed.”*

Regulatory Operations Branch and Technical Support Branch will conduct a review of how they can work together in a more harmonized manner. This will examine how they work together for assessments and compliance inspections that impact both safety and security, and overall communication processes to ensure that security staff and licensing/compliance staff do not work in isolation of each other. The conclusion of the review will be the formalization of the respective roles and responsibilities within the CNSC (first phase: NPPs), and the development of a generic CNSC communications protocol with licensees that will address both safety and security (an existing Harmonized Plan initiative).

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 and managing their revision and production of new ones including new regulatory framework documents.

Corporate Services Branch

The Corporate Services Branch provides general services necessary for the functioning of the Regulatory Operations Branch and other parts of the CNSC. Functions such as managing labour relations and compensation, training delivery, and human resource planning, are key provisions under subsection 8.1 c below.

**8.1 c      Maintaining competent staff**

Maintaining a skilled, knowledgeable and dedicated workforce is critical to the CNSC’s success. One of the actions on Canada from the Third Review Meeting was to maintain safety competence at the regulatory body.

As a departmental corporation of the Government of Canada with revenue spending authority, the CNSC is in the position to effectively set employment conditions for staff to meet regulatory needs in the context of the larger nuclear industry. The IRRS mission report stated, as a particular strength of Canada, that “the recruiting process is facilitated by optimized employment conditions provided by the CNSC.”

The CNSC has been highly successful in attracting new employees over the past three years. While there are some skill sets that are more challenging to fill, CNSC has been able to meet its recruitment objectives. CNSC grew by

- 13% in 2007–08
- 17.3% in 2008–09
- 5.6% in 2009–10.

Given that the CNSC reached its optimal workforce levels in 2009–10, the CNSC is shifting its efforts from high levels of recruitment to retention. In this regard, the human resources priorities are to develop and retain talent, to sustain CNSC’s ability to attract a highly qualified workforce and to develop organizational flexibility.

Good Practice G2 from IRRS Mission

*“The authority of CNSC to independently define its own employment conditions is considered to be a good practice.”*

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The CNSC utilizes this authority to create optimal employment conditions that assist in attracting and retaining highly qualified staff.

Over the past two years, senior CNSC management has placed priority on addressing potential succession issues within the management cadre, by identifying critical positions that may be at risk due to potential retirements, and undertaking appropriate succession planning through recruitment and/or development. These efforts will continue in the future.

A formal Individual Learning Plan process was launched in summer 2008, and by fall 2008 all CNSC employees had a learning plan in place. In 2009, the electronic Individual Learning Plan was launched, to facilitate the process for employees and managers. These plans contribute to CNSC’s strong learning culture, by ensuring immediate and future learning needs are identified. This approach will help CNSC meet its evolving business priorities and objectives.

CNSC offers over 100 ongoing technical and non-technical sessions to its staff. During the reporting period, the CNSC continued to contribute to CANTEACH and University Network of Excellence in Nuclear Engineering programs, which are discussed in subsection 11.2 b.

In addition, the CNSC is enhancing its Leadership Development Program, revamping the New Employee Orientation Program, and continuing the implementation of its Inspector Training and Qualification Program, as described in the following paragraphs.

The revised Leadership Development Program will provide a focused approach for both emerging and seasoned leaders, to further develop their style of leadership, create a culture of collaborative managers who understand the environment in which CNSC operates, and prepare them to take on higher and broader roles and responsibilities in the future. Group assessments based on the ‘360 degree’ concept will be held in the next reporting period, to establish a baseline of the leadership profile at CNSC, in order to build organizational strengths and improve in key areas.

The Orientation Program was revised in 2009, to provide more in-depth guidance to new scientific and administrative professionals in understanding the CNSC's culture, structure, mission and values, to promote the CNSC as an 'employer of choice', and to instill the CNSC vision to 'be the best nuclear regulator in the world'. The program's objective is to facilitate the integration of new employees into the CNSC, and establish the initial steps towards long-term retention. The first revised orientation session will be delivered in the next reporting period.

The Inspector Training and Qualification Program was launched in 2009, as part of the Harmonized Plan. It entails the development and implementation of an effective, standardized and systematic approach for training and qualifying all CNSC inspectors. The program is composed of a combination of common training, service-line specific training and on-the-job training.

As part of the Inspector Training and Qualification Program, DPRR developed a systematic approach for NPP-related knowledge and on-the-job-training for power reactor site inspectors. This program includes a training plan that identifies the common inspector and specific training for power reactor site inspectors, on-the-job training and evaluation manuals, and a training qualification record that documents the inspector's progress. An inspector card is only issued when the site supervisor at the NPP determines that the candidate 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 card.

#### **8.1 d Management System — supporting processes and programs**

The CNSC Management System presents an integrated approach to managing the performance of mandated functions across the organization, linking the regulatory framework, people, processes, and resources. The CNSC Management System meets requirements specified in applicable acts, regulations, codes, standards, directives, and policies of the Government of Canada. Senior CNSC management also specifies additional requirements for the Management System. The CNSC's vision, to 'be the best nuclear regulator in the world', includes alignment with, and benchmarking against, recognized international regulatory best practices. The CNSC Management System conforms to the IAEA document *Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety* (GS-R-1) and related safety standards.

One of the actions on Canada from the Third Review Meeting was to complete the implementation of the management system at the CNSC. The CNSC Management System was the subject of extensive review during the IRRS mission. The IRRS mission report stated, as a particular strength of Canada, that the CNSC has done extensive and commendable work over recent years to improve the Management System by moving the organization from an expert-based system to a more process-based system. The report further recommended that the CNSC complete the development of the Management System and increase its alignment with IAEA document *The Management System for Facilities and Activities* (GS-R-3).

Recommendation R12 from IRRS Mission

*“CNSC should more clearly envelope and timeframe the remaining efforts to complete the Management System according to GS-R-3 and for that purpose update the Harmonized Plan.”*

A critical review of the remaining work required to align the CNSC’s Management System with GS-R-3 has been completed. Firm timelines for addressing remaining work will be determined during the next revision of the Harmonized Plan.

The IRRS peer review team also made two recommendations related to the development and implementation of mechanisms to review and improve the Management System.

Recommendation R13 from IRRS Mission

*“CNSC should develop a methodology and implement Management System reviews to be conducted at planned intervals by internal or/and external resources. This programme should ensure the continuing suitability and effectiveness of the Management System as a whole and its ability to enable the objectives of the organization to be met. One important factor to be reviewed in this perspective is the application of the graded (risk-informed) approach to the regulation of facilities and activities.”*

The CNSC plans on conducting a complete review of the Management System in the next reporting period. The review will include a review of the suitability, effectiveness of the Management System, its alignment with organizational objectives and the effectiveness in applying a graded (risk-informed) approach in the regulatory activities.

Recommendation R14 from IRRS Mission

*“CNSC should implement a mechanism to regularly identify opportunities for improvement of the Management System and should evaluate the effectiveness of the improvement actions.”*

As noted in response to Suggestion S17 (see below), the CNSC will continue to identify the opportunities for improvement of the Management System through self-assessment exercises and internal audits. In addition, the CNSC will enhance the Management System intranet site and introduce a bulletin board, to provide another mechanism for staff to provide feedback and identify opportunities for improvement. CNSC management will evaluate the effectiveness of the improvement action plans, to determine whether any further improvements are needed.

Management System Manual and Key Processes

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

The CNSC issued a major revision of its *Management System Manual* in October 2008, and revised it further in May 2009. The purpose of the manual is describe for CNSC employees how the Management System integrates the regulatory framework, people, processes, and resources to



manage all work across the organization and ensure consistent quality results. It identifies the high-level policies, principles, and processes by which the CNSC achieves its goals and objectives. The manual is supported at lower levels by process documentation and related procedures that guide staff and collectively provide details on how CNSC performs its work.

The *Management System Manual* identifies the CNSC's key processes:

- Management processes
- Core processes (Manage the Regulatory Framework, Manage Licensing and Certification, and Assure Compliance)
- Enabling processes

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

Suggestion S17 from IRRS Mission

*“CNSC should supplement the internal audit programme in order to provide feedback to senior management on the development and implementation (and output) of the Management System processes. To support this programme, a number of internal auditors representing different parts of the organization could be used. In connection with the audit programme, a systematic approach to the management of non-conformances and potential non-conformances of processes and products should be developed and formalized.”*

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The CNSC's internal audit function takes into consideration the Management System processes as part of the audit universe during the annual development/update to the risk-based audit plan. The CNSC will identify staff from across the organization to conduct self-assessment of processes. In addition, these same resources will act as liaisons to solicit employee feedback, identify non-conformances, and facilitate the identification and implementation of Management System improvements through a formal change management process. This will be completed as an initiative under the Harmonized Plan.

CNSC staff review procedures are important process-related documents that govern coordinated assessments of submissions from licensees and licence applicants. The development of these procedures continued during the reporting period. They are intended to foster consistent and transparent approach for the oversight of regulated facilities. CNSC staff review procedures are described in subsection 7.2 (ii) a and subsection 14 (i) c.

During the reporting period, the CNSC management continued to review and update its decision making practices, for the purpose of improving their timeliness and effectiveness. Each of the key licensing directorates (Directorate of Power Reactor Regulation, Directorate of Nuclear Cycle and Facilities Regulation, Directorate of Nuclear Substance Regulation) has risk-informed tools and processes to assist in their respective decision making processes, and for the allocation of resources to priority activities. The CNSC continues to integrate risk-informed decision making into all key processes, as part of strengthening the Management System.

### Risk-Informed Decision Making (RIDM)

Good Practice G-2 for Canada from the Fourth Review Meeting

*“application of the risk-informed decision making approach, in particular for prioritization of safety issues and planning resource utilization”*

The CNSC risk-informed decision making (RIDM) process, based on CSA document *Risk Management Guideline for Decision Makers* (Q850), was developed in 2005 and issued for a one-year trial in 2006. RIDM is designed to systematically decide the best of course of action for addressing issues such as licensing issues and generic safety issues. Since its introduction, the process has been revised based on input from both the CNSC and the Canadian NPP industry. It has been validated and successfully applied by CNSC staff and management in several applications.

RIDM was approved by CNSC management in April 2008, for use in the core activities of licensing, compliance and planning and is referenced in the *CNSC Management System Manual*.

In addition to contributing to the CNSC’s transition towards process-based decisions, RIDM:

- ensures that all risks are identified and considered for making decisions
- ensures the interests of affected stakeholders are considered
- provides decision makers with justification for decisions
- enables decision-makers to make easier-to-explain decisions
- contributes to better communication through the use of a standardized set of terms to describe risk issues
- provides for the explicit treatment of uncertainty

Challenge C-6 for Canada from the Fourth Review Meeting

*“implement more fully the risk-informed decision making process”*

The risk-informed decision making process is seeing increased use for a variety of regulatory decisions and situations. An increasing number of CNSC staff is getting experience in its application, and NPP industry members are also becoming familiar with it and endorsing its use. During the reporting period, the RIDM process was applied to several power reactor licensing applications requiring regulatory decision. A more detailed description of the RIDM process and an example of its application in a regulatory decision are provided in Appendix H. RIDM was also used to risk-rank about 75 CANDU safety issues and to develop the path forward for resolution of the most significant ones (e.g., by guiding research effort). A CNSC-industry exercise further validated the process and identified mutually acceptable resolution paths for the outstanding safety issues (see subsection 14 (i) and Appendix G for details).

Good Practice G6 from IRRS Mission

*“The development and use by CNSC of processes and tools for risk informed decision making”*

The risk-informed decision making process will continue to be used and improved where necessary.

Planning Process for Regulatory Activities

The CNSC organizes its regulatory activities for NPPs by creating, implementing, monitoring and adjusting regulatory work plans for each NPP. Work plans are reviewed to ensure they cover specific goals and are consistent among NPPs regarding the planning of inspections, reviews and other regulatory activities. Activities in each NPP plan are also consolidated into a summary plan known as the Regulatory Activity Plan, which is costed to establish an estimate of the annual licence fee for each NPP. The Regulatory Activity Plan, along with a notification containing the licence fee estimate, is sent to each licensee in advance of each fiscal year.

The CNSC has been working toward establishing fully integrated planning and performance management processes and tools. A strategic plan, supported by environmental scans and corporate risk profiling, will be created in the next reporting period. An improved process for monitoring and review will also be implemented in the next reporting period.

Suggestion S16 from IRRS Mission

*“CNSC should continue integration of its strategic and annual planning processes as well as its in year control and monitoring processes for better invoices to licensees and to ensure alignment and reallocation of resources according to corporate priorities. For this purpose CNSC should consider the integrated use of performance indicators for each programme activity and related processes.”*

The CNSC has been working toward establishing fully integrated planning and performance management processes and tools. This encompasses the creation of strategic plans and objectives, and their translation to multi-year and annual activity plans that are linked to clear performance targets and objectives. The processes will also include continual monitoring of plan execution, performance and evolving external factors that are important to making timely and informed adjustments to regulatory plans and activities, both in-year and longer-term. Strategic planning for the period 2010–15 (supported by an environmental scan and corporate risk profile) is underway. An improved process for monitoring and mid-year review, re-forecasting and adjustment of current fiscal year work plans to address evolving pressures and strategic priorities is being developed and implemented.

CNSC Research and Support Program

The CNSC Research and Support Program provides staff with access to independent advice, expertise, experience, information and other resources, via contracts or contribution agreements, placed with the private sector as well as other agencies and organizations in Canada and internationally. The work undertaken through the Research and Support Program is intended to support staff in meeting the CNSC’s regulatory mission. Each year, the program is reviewed and

evaluated, the need for research and support in the following year is identified, and a commensurate budget is allotted. The CNSC Research and Support Program is independent of the extensive research and development program conducted by the industry. Appendix E describes the research programs and projects for the CNSC (and the Canadian nuclear industry) during the reporting period.

The IRRS mission review team noted the need for a more systematic alignment between the CNSC Research and Support Program and regulatory priorities.

Recommendation R1 from IRRS Mission

*“CNSC should initiate a periodic strategic planning programme to define both short term and longer term research activities needed to support pending and potential regulatory decisions.”*

The CNSC will review and refocus the CNSC’s research onto mission-critical knowledge areas and gaps. That is, knowledge needed to address immediate regulatory issues and potential future challenges, such as those that may be posed by advanced and experimental reactor and other facility designs, novel and sophisticated analytical tools and methods, and related advancements in fundamental science and engineering, including nuclear, physical, environmental, health and social sciences.

Recommendation R2 from IRRS Mission

*“Sufficient resources for research activities should be allocated to support the outcome of the strategic planning programme.”*

The CNSC intends to re-align the scope of its current research activities with its longer-term strategic needs (as noted above in response to IRRS Recommendation R1) and secure incremental funding to meet these needs. The ultimate depth and breadth of the CNSC research program will be subject to the CNSC’s ability to secure additional resources.

### **8.1 e      Readiness for new-build**

During the reporting period, CNSC staff continued to assess and improve its readiness for new-build projects. Improvements in the integration and consistency of technical assessments were ongoing. Improvement initiatives related to licensing (see subsection 7.2 (ii)) will be applied to new-build licence applications. Progress was made in preparing regulatory framework documents that are applicable to new-build (see subsection 7.2 (i) c). It is noted that initiatives related to new-build preparations help inform the conduct of activities related to operating facilities, and vice versa.

Suggestion S9 from IRRS Mission

*“The CNSC should refine existing plans and confirm its organizational readiness (e.g. structure, staffing, skills) to support the transition from the project planning phase to the technical review of new design applications, inspection of construction activities and oversight of the start-up and operations.”*

The CNSC is continually revisiting its organizational readiness for new build projects.

Organizational readiness – work has progressed on the needed regulatory documentation (e.g., guidance documents, application guides, application forms, staff review procedures etc.) in preparation for review and assessment work. In parallel, the CNSC has commenced work on the compliance program that will be used once the projects move from the design stage to construction, commissioning and operations.

Transition - work has commenced in identifying organizational requirements, staffing complements and skill sets for inspectors to implement the compliance program.

Planning - A comprehensive life cycle plan is being developed that outlines the strategic steps needed to assure organizational readiness as the new build program progresses from site preparation to construction to operation.

### 8.1 f Collaborative approach to resolution of high-level safety issues

Good Practice G-3 for Canada from the Fourth Review Meeting

*“Establishment of an operational forum for high-level executive discussions between the regulator and the industry on policy issues and path forward”*

Recognizing the need for an effective channel of high-level communication between the NPP licensees and the CNSC, the Chief Nuclear Officer/CNSC Executive Forum was established at the end of the previous reporting period. The Chief Nuclear Officer/CNSC Executive Forum has provided an effective means to discuss strategic issues that involve both licensees and the CNSC, thereby promoting understanding and helping to focus action on safety issues related to NPPs.

This forum is used to identify strategic challenges and opportunities that may influence the nuclear power industry in Canada and the CNSC, and to facilitate mutual understanding. The forum continued to evolve and help focus efforts to address various safety issues during the reporting period. Although the forum is not a mechanism for regulatory decision making, it has facilitated dialogue on:

- existing and emerging issues pertaining to the CNSC’s mandate for health, safety, security, and the environment
- new industry developments, major projects etc
- respective focus areas and strategic plans and priorities where practical and appropriate

## 8.2 Status of the Regulatory Body

### 8.2 a Separation of CNSC and organizations that promote and utilize nuclear energy

The passage of the NSCA created distinct, enabling legislation for the regulation of nuclear activities and the separation of 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 and the protection of the environment, as well as the implementation of international obligations. The mandate does not extend to economic matters.

The Commission Tribunal is defined as a court of record in the NSCA, which allows it to conduct its matters in an independent manner. The NSCA provides that only the governor in council may issue directives to the Commission Tribunal, 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. A recent example can be found in the *Directive on Health of Canadians* (described in subsection 8.2 b).

To safeguard the integrity of the Commission Tribunal's role as an independent decision-maker, contact between the Commission Tribunal and CNSC staff occurs through the Secretariat. With the exception of the Secretariat and the president, CNSC staff has limited interaction with the Commission Tribunal outside of hearings. The independence of the CNSC from NRCan, which sets general nuclear policy for Canada, was assessed in detail during the IRRS mission. The IRRS mission report concluded the following:

*“Because of NRCan’s role as appropriate ministry for both the CNSC and AECL, as well as a CNSC licensee, the IRRS Team closely inquired into the de jure and de facto independence of the CNSC from NRCan. On the basis of the CNSC self-assessment and interviews with CNSC and NRCan, the team noted:*

- *NRCan acts as the administrative channel for the Commission. The CNSC submits its Reports through the Minister of NRCan to Parliament;*
- *NRCan has limited executive powers on the CNSC e.g. it can request reporting on issues concerning the general administration and management of the affairs of the Commission (NSCA, section 12(4));*
- *All significant decisions like the appointment of Commissioners, the issuing of directives and the approval of regulation are taken by the Cabinet as whole and enacted by the Governor in Council; and*
- *A member of the Commission may only be removed from its function by the Governor in Council for misconduct.*

*The IRRS Team agrees that the Canadian arrangements meet the requirements of 2.2(2) of GS-R-1”.*

### 8.2 b Other mechanisms that facilitate regulatory independence

Other mechanisms that help maintain the independence of the CNSC include a strong, risk-informed framework for decisions, strong communications within the organization and externally, and a strong framework for ethical and responsible action. These are described in more detail below.

### Guidance and Structure for Decision Making

General guidance to the CNSC was provided in December 2007 for important decisions involving different types of risks. The *Directive to the Canadian Nuclear Safety Commission Regarding the Health of Canadians* states the following.

*“In regulating the production, possession and use of nuclear substances in order to prevent unreasonable risk to the health of persons, the Canadian Nuclear Safety Commission shall take into account the health of Canadians who, for medical purposes, depend on nuclear substances produced by nuclear reactors.”*

The explanatory notes of the directive indicated that it was necessary to protect the health of Canadians at a time when a serious shortage of medical isotopes in Canada and around the world had put the health of Canadians at risk. This directive addresses the outstanding issue for all Contracting Parties identified at the Fourth Review Meeting.

Nuclear regulatory independence regulatory independence is facilitated by a strong framework for decision making that is aligned with the CNSC’s mandate and based on a rational, balanced consideration of risk. The adoption of RIDM (described in subsection 8.1 d) has formalized the decision making process so that risk is considered systematically.

### Strategic Communications

Part of the CNSC’s mandate is to disseminate relevant information to all stakeholders (see subsection 7.1 a). The CNSC is committed to openness and transparency with regard to its affairs and the undertakings of the Commission Tribunal. By fostering open interaction and communication with its stakeholders, the CNSC continuously gathers input from all parties with an interest in Canada’s nuclear industry. This helps to prevent undue influence from any one party or concern.

During the reporting period, the CNSC continued to focus its outreach activities on heightening public awareness and understanding of its role and of regulated nuclear activities. There has been enhanced engagement with diverse stakeholders, including municipal governments in the region of major facilities, media, provincial officials, professional associations and non-governmental organizations. Recognizing that communities with nuclear facilities have concerns about how these facilities may affect health and safety, the environment and the local economy, the CNSC maintains open lines of communication with the Canadian Association of Nuclear Host Communities.

In 2007 and 2008, following the publication of the annual *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants*, CNSC staff held public information meetings in nuclear power plant host communities in Ontario, Quebec and New Brunswick. Staff presented stakeholders with the safety results for each NPP, and updated attendees on other topics of interest specific to these communities, including waste management, new-build projects and refurbishment of existing reactors.

The CNSC has held numerous hearings in communities most affected by the Commission Tribunal’s work. To ensure the needs of future stakeholders are met, the CNSC is proactively contacting communities likely to become involved in nuclear activities, such as mining, milling

and new NPPs throughout the next decade, to explain the regulatory process and respond to questions.

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

- regional meetings with industrial radiography licensees to clarify regulatory requirements
- a forum with licensees to provide an update on the State-Level Integrated Safeguards Approach for Canada
- participation in the Utility Certification and Training Advisory group, involving policy-level discussions about the training and certification of NPP personnel
- participation in CANDU Owners Group Nuclear Safety Committee meetings, as well as meetings of the Chief Nuclear Officer/CNSC Executive Forum (see subsection 8.1 f) to promote common understanding of generic safety and licensing issues

During the reporting period, the CNSC participated fully in the development of the Government of Canada's approach to consulting with Aboriginal groups on major resource projects. The CNSC's interaction with Aboriginal communities is guided by the *Interim Guidelines for Federal Officials to Fulfill the Legal Duty to Consult*, issued in February 2008. To help meet its legal obligations for Aboriginal consultation on CNSC-regulated projects, in March 2010, the CNSC published its "Codification of Current Practice: CNSC Commitment to Aboriginal Consultation."

In its ongoing efforts to improve transparency and dispel myths, the CNSC's Web site was revamped in 2008–09 to provide convenient access to a greater range of information for licensees, the Canadian public and other stakeholders. The organization launched an online comment form to expand its consultations for draft regulatory documents, which are made available for stakeholders to provide input. Stakeholders may also provide input by facsimile, email and conventional mail. Hearings of the Commission Tribunal are also open to the public, and are now broadcast over the Internet for all to see.

#### Audit, Values and Ethics

The CNSC's Audit Committee ensures that the president has independent, objective advice, guidance and assurance on the adequacy of the CNSC's control and accountability process. The committee also reinforces the independence of internal audits. Its oversight responsibilities extend to key areas and processes that include values and ethics, risk management, management control, and accountability. The committee has three external members, appointed by Treasury Board, and two internal members.

The Values and Ethics program, launched in 2005 as the Values and Ethics Strategy, aims to strengthen the CNSC's ethical climate. It nurtures a culture of trust that encourages employees to come forward with their concerns without fear of reprisal, and to provide external stakeholders with sound information that enables them to fulfill their mandate.

As per the 2005 CNSC Values and Ethics Strategy's three-year plan, an independent evaluation was conducted in 2007 to assess the program's relevance, implementation and progress. In



pursuit of the CNSC's goal of continued improvement, CNSC management recommended that vice-presidents include values and ethics awareness and practice in their management performance contracts, and that managers offer active support for staff engagement in values and ethics training. Moreover, the Office of Audit and Ethics committed to increasing its efforts in promoting the strategy through regular communications, individual outreach, posting of ethical case studies on the intranet, and the delivery of values and ethics training sessions to staff. The number of employees who participate in the ethics awareness sessions and the large number of virtual hits recorded on the values and ethics external and intranet Web sites demonstrate the success of the implemented steps.

A new Values and Ethics Code for the Public Sector will be tabled in the Parliament of Canada, as stipulated in the Public Servants Disclosure Protection Act. The code, expected to be published in the next reporting period, institutes respect for democracy, respect for people, integrity, stewardship and excellence as the public sector's values. It requires deputy heads and senior officers of federal departments and agencies responsible for disclosure to foster a positive culture of values and ethics, and to ensure that employees are aware of their rights and obligations under the code. The CNSC will consult with staff to develop the CNSC values and ethics code.



## **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**

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 Tribunal. As stated in subsection 7.2 (ii), the Commission Tribunal can only issue licences to applicants that are qualified to operate the NPP, and will adequately provide for the health and safety of persons and the protection of the environment.

Section 12(1) of the *General Nuclear Safety and Control Regulations* assigns various responsibilities to the licensees related to nuclear safety. Subsection 12(1)(c) requires the licensee to take all reasonable precautions to protect the environment and the health and safety of persons. Other subsections assign responsibility to the licensee to:

- provide and adequately train 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 other measures related to possible illegal activities, security and sabotage

The prime responsibility of the licensees is affirmed in the CNSC regulatory policy *Regulatory Fundamentals* (P-299), which states the following:

*“Those persons and organizations that are subject to the NSCA and regulations are directly responsible for managing regulated activities in a manner that protects health, safety, security, and the environment, while respecting Canada’s international obligations.”*

### **9 b Canadian approach to ensuring responsibility is fulfilled**

The CNSC is responsible to the Canadian public for regulating licensees, in order to assure they carry out their responsibilities properly. The CNSC achieves this in the following ways:

- setting requirements and assuring compliance
- basing regulatory action on the level of risk
- making independent, objective and informed decisions
- serving the public interest

For the most part, Canada has a relatively non-prescriptive nuclear regulatory regime for NPPs that sets general requirements and performance standards. To assure compliance of the licensees, 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 approach
- uses appropriate industry, national, international or other standards

These regulatory activities are described in more detail in subsections 7.2 (i), (ii), (iii), and (iv).

This regulatory approach aims to set basic requirements that allow the designers and licensees some flexibility to meet fundamental safety requirements in a manner that best meets their needs. Licensees must demonstrate that NPP operations satisfy performance standards, and that facilities will continue to meet applicable criteria throughout their designated operating lives.

Licensees are responsible for addressing these requirements and criteria in their systems, programs, processes, and designs. Descriptions of these provisions are submitted to the CNSC at the time of licence application. Examples of these provisions include, the overall safety policy (see Article 10), operating policies and principles (OP&P; see below), program descriptions (see Appendix C), and the design of safety-related systems (see Article 18).

If accepted by the CNSC, these provisions become part of the licensing basis (defined in subsection 7.2 (ii) a) for an NPP, and dictate future regulatory activities, such as inspections and change approvals. The renewal of operating licences (typically every five years) re-affirms the responsibility of the licensees; the inclusion of new standards in the licences re-defines the extent of that responsibility, relative to modern practices, on a regular basis.

Between licence renewals, the CNSC compliance program assures that licensees meet their defined responsibilities. The CNSC maintains trained, experienced inspectors at all NPP sites on a permanent basis, who 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 standard *Reporting Requirements for Operating Nuclear Power Plants (S-99)*, which establishes reporting requirements for safety-significant developments and non-compliance with legal requirements (subsection 7.2 (iii) b contains details on S-99).

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 c Specific means by which licence holders discharge safety responsibility**

During operations, licensees fulfill their responsibilities through the following activities:

- operating in accordance with the licensing basis (see Article 19)

- defining safe operating limits and working within them (see subsection 19 (ii))
- implementing managed systems to control risks associated with NPP operations (see Articles 10 and 13)
- developing an organizational culture committed to ensuring safe NPP operation (see Article 10)
- monitoring both employee and facility performance to ensure expectations are met (see subsections 12 h, 14 (ii) a, and 19 (vii))
- ensuring that adequate resources are always available to respond to planned activities and contingencies (Annex 11.2 b)

Many of the specific provisions used by each Canadian licensee to discharge its responsibility for safety is described in its OP&P document, which is submitted in support of a licence application. The OP&Ps provide direction for operating the nuclear facility safely, and reflect a safety analysis that has been submitted to the Commission Tribunal, or a person authorized by the Commission Tribunal, as part of the licence application. For each NPP, the OP&P document explains how licensees shall operate, maintain and modify systems to maximize nuclear safety and keep consequential public risk acceptably low. The OP&Ps specify operating limits, as well as procedural and administrative limitations for safety systems and safety-related systems. Operation in states not considered in, or bounded by, the safety analysis is not permitted. OP&Ps also define the authority and responsibilities of managers and operating staff (see subsections 19 (ii) and 19 (iii) for details on OP&Ps).

The CNSC must approve the initial OP&P document submitted with the application for an operating licence. Any changes to the operating limits for safety systems and safety-related systems that are stated in the OP&Ps require prior consent from the Commission Tribunal or a person authorized by the Commission Tribunal, as explained in subsection 7.2 (ii) d.

Although the licensing mechanism is in place to ensure each 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.

All NPP licensees in Canada are members of the CANDU Owners Group (COG), which is 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. It has provided the mechanism for many projects to improve the safety of CANDU reactors; several examples are provided throughout this report.

The Canadian Nuclear Utility Executive Forum, which includes senior representatives from all licensees and AECL, facilitates a coordinated approach to resolve significant technical and regulatory issues and interact with the CNSC. It provides high-level direction to, and oversight of, the work done by functional 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 Canadian Nuclear Utility Executive Forum,

which helps ensure the alignment of the high-level direction with ongoing COG programs and projects.

The Canadian nuclear executives also engage in high-level communications with CNSC executives—see subsection 8.1 f.

### Proactive Disclosure

NPP licensees have a regulatory requirement to develop and implement a public information program to inform people living in the vicinity about their operations. As well, the CNSC promotes openness and transparency on the part of licensees, in their relations with community representatives, their target audiences and the public. Licensees are encouraged to proactively disclose information to the public about routine and non-routine releases of radiological and hazardous materials and about unplanned events, such as exceeding regulatory limits or industrial accidents. The CNSC is presently drafting regulatory and guidance documents to formalize the requirements for a public information program with a public disclosure protocol.

### **9 d Summary of fulfillment of safety responsibilities during reporting period**

During the reporting period, licensees fulfilled the basic responsibilities for safety as required by the NSCA. The CNSC did not need to engage in formal enforcement action (requests from the Commission Tribunal, orders, licensing action, or prosecution, as described in subsection 7.2 (iv)) to resolve safety-related issues at Canadian NPPs. The CNSC's regulatory activities involving promotion and verification of compliance were sufficient in addressing and resolving safety-related issues, and were adequate regulatory tools to maximize conformance with regulatory requirements by all NPP licensees.

The licensees' fulfillment of their responsibility to safety was manifested by the strong safety record of the Canadian NPPs during the reporting period, as described throughout this report.

## **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 Resources

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 facilities 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 of these organizations to external comparison, peer review, and improvement. For example, the NPPs regularly participate in World Association of Nuclear Operators assessments (see subsection 14 (ii) d). The CNSC also demonstrated a commitment to peer review and improvement, by hosting an IRRS mission (see Article 8). A brief description of measures related to the prioritization of safety at CNSC is provided at the end of this article.

### **10 a Establishment of policies and supporting processes that give due priority to safety**

In order to make safety an overriding priority, the executive and management of an organization must state and demonstrate safety as a core value. The management system must consistently uphold and restate this priority at all levels of the management structure.

At the end of the reporting period, most NPP operating licensees in Canada referenced the ‘old’ CSA-N286 series on quality assurance (QA; see subsection 13 a) that requires a high-level policy statement committing all levels of the organization to a QA program. However, some licences now refer to the new CSA standard on *Management System Requirements for Nuclear Power Plants* (N286-05). A primary purpose of the new standard is to promote safe and reliable operation of NPPs via a commitment and adherence to a set of management system principles. During the next reporting period, it is anticipated that N286-05 will be added to more operating licences when they are renewed.

All licensees have implemented the principles in their management systems and have established policies that give due priority to nuclear safety. The implementation of the principles found in these policies differs by licensee, as described in Annex 10 a. The CNSC reviews these management systems prior to issuing licences, to ensure they adequately support the applicant’s provisions to protect health and safety. The QA program (see Article 13) provides assurance that policies, principles and high-level safety requirements are adequately carried through to licensee activities.

Commensurate with international practices, Canadian NPP licensees have developed processes in their management system structure that ensure safety is the overriding priority. These 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. 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 resolve

indeterminate or known degraded conditions that impact on plant safety. These processes continue to mature each time they are used, and the lessons learned are shared with the other licensees. Other practices, such as management presence in the field and oversight committees, also help maintain the priority on safety.

## **10 b Safety culture at the NPPs**

### General Approach

Safety culture at the 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; embracing organizational learning; and promoting a ‘just culture’ in which the aims are 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. The senior management is ultimately responsible for the safety of the plant, and therefore is expected to develop processes to encourage and track the effectiveness of safety programs and to demonstrate by their actions that safety is of overriding concern. Supervisors’ behavior 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 to adhere to, all rules, policies and regulations related to nuclear safety, radiation safety, industrial safety, and fire protection. 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 for problem identification and corrective action.

### Safety Culture Self-Assessments

The greatest benefit of a safety culture assessment is the learning opportunity that it creates. However, for a safety culture self-assessment, it is recognized that there is potential for licensees to overlook key topics or circumstances, due to complacency and over-familiarity with internal ways of conducting business. The industry has taken two approaches to try to overcome the potential for ‘organizational blindness’:

- the development of common safety culture assessment guidance and information exchange among Canadian NPP licensees through the COG Human Performance Working Group
- the inclusion of safety culture as part of regular third-party assessments by other industry organizations

The following documents are among those used as the basis to self-assess safety culture at NPPs:

- INSAG 4, *Safety Culture*, IAEA, Vienna, 1991

- INSAG-13, *Management of Operational Safety in Nuclear Power Plants*, IAEA, Vienna, 1999
- INSAG-15, *Key Practical Issues in Strengthening Safety Culture*, IAEA, Vienna, 2002
- The CNSC draft document *Guidance for Licensee Self-Assessment of Safety Culture*

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

### Ontario Power Generation

OPG continues to use nuclear safety culture assessments, to facilitate improvements in fostering a strong nuclear safety culture. OPG conducts a comprehensive nuclear safety culture self-assessment once every three years at each NPP. During the reporting period, each NPP completed another nuclear safety culture assessment.

The assessment process has been refined based on the lessons learned from each preceding assessment. Enhancements to both the staff survey tool and the onsite assessment process have been made, to facilitate the collection and consistency of assessment inputs. In addition, the NPPs are now required to complete a post-assessment follow-up, to identify nuclear safety culture issues and develop appropriate corrective actions.

One of the major results arising from both nuclear safety culture assessments and internal nuclear safety management audits at OPG was the need to raise the awareness of nuclear safety and reinforce its overriding priority. This focus was one of the top-five OPG priorities in 2009.

### Hydro-Québec

In January 2008, during an operational peer review, a safety culture self-assessment was conducted at Gentilly-2. The self-assessment demonstrated that staff possessed an understanding of the safety culture at Gentilly-2. Notwithstanding, in 2008 a new safety policy on nuclear safety at the NPP was promulgated to all staff.

Positive exchanges between management and staff have helped establish clear expectations with respect to each individual's role in the maintenance of a strong safety culture at Gentilly-2.

### Bruce Power

Bruce Power carried out safety culture self-assessments in 2001, 2005 and 2008. The following key strengths were highlighted in the 2008 assessment:

- Strong safety culture is recognized as a top priority and core value — employees are aware, supported by training, accountable, and ultimately feel safe (managing and holding contractors to same standards is an opportunity for improvement).
- Communication is a clear strength to be leveraged.
- Employees are clear on what Bruce Power is aiming to accomplish, and have endorsed that direction.

The areas that were identified for improvement were:

- employee performance management

- process quality
- operating efficiency
- holding contractors to the same level of commitment to safety as licensee staff

Bruce Power has developed a corrective action plan to address the areas for improvement, and will be conducting another assessment in the next reporting period.

High-scoring areas benchmarked against other high performing nuclear and non-nuclear companies included communication, safety and career development. In addition to conducting the self assessments, Bruce Power has also delved deeper into employee opinion, through regular, randomly-generated but statistically valid surveys, using common industry questionnaires.

#### Atomic Energy of Canada Limited

Safety culture workshops are held on an ongoing basis, to create a common understanding of safety culture across the organization. AECL has introduced specific training and workshops/self-assessments of safety culture for senior management, supervisors and designers and engineering project staff. The safety culture training includes safety culture awareness, safety culture workshop manuals, training sessions and follow-up self-assessments. Part of the safety culture awareness program examines in depth specific lessons learned (OPEX) from the nuclear industry (CANDU and other technologies) and other related industries.

#### **10 c          CNSC assessment of safety culture at the NPPs**

The CNSC uses the IAEA definition of 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”.*

The CNSC also makes a clear distinction between nuclear safety and conventional health and safety, but recognizes that safety culture can impact both. The importance that the role of safety culture plays in influencing the organizational processes in high-reliability organizations has been demonstrated through research conducted by the CNSC and others; as such, safety culture has become a particular focus for the CNSC.

The CNSC review of organizational performance (also discussed in subsection 12 g) considers the influence of organizational structures, roles and responsibilities, communications, other team processes, and policies on safety performance at Canadian nuclear facilities (see Article 12 for more discussion on human factors technical review areas). For example, safety performance 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 individual line staff that carry out the operational work tasks.

CNSC staff assesses the licensees’ organizational performance in order to ensure that safety functions and safety culture influences on human performance — such as structures, policies, and processes — support the safe conduct of the nuclear activity. Organizational performance is

monitored and assessed through a number of activities, such as desktop reviews, regulatory inspections, and licensee self-assessments.

CNSC staff use a process termed the organization and management review method to evaluate organizational influences on licensees' safety culture. The method is a long established, validated, objective and systematic approach. It has been used extensively to conduct baseline assessments of the organizational and management attitudes and behaviours at all operating NPPs in Canada.

In 2009, the organization and management review method was used where a root cause analysis of an event at one of the NPPs had identified possible weaknesses in the organization's safety culture. The assessment identified particular weaknesses, which the licensee addressed in a corrective action plan. Following a review by the CNSC, this plan is now being implemented.

In the last few years, the CNSC has increased its attention to events that are reported by licensees in accordance with CNSC document *Reporting Requirements for Operating Nuclear Power Plants (S-99)*. Such events are analyzed against the CNSC's organization and management characteristics. This process allows the CNSC to observe emerging trends in the licensee's safety culture.

CNSC staff also checks for other indicators of positive safety culture at NPPs, such as whether:

- documentation exists that describes the importance and role of safety in operation of organization
- good housekeeping, material condition and working conditions are maintained
- use of self-assessment is evident
- an organizational process exists for conflict resolution and it is effectively used
- a questioning attitude is evident at all organizational levels

The CNSC draft document *Guidance for Licensee Self-assessment of Safety Culture* has been distributed to NPP licensees for guidance, and was used as a framework for commenting on self-assessments done by several facilities. It is also noted that some licensees benchmarked their self-assessments results against the world's top nuclear and non-nuclear performers, and CNSC staff consider these activities to represent further maturation of the approach.

#### **10 d Future direction**

Until recently, much of the focus on safety culture at NPPs has been on understanding what it is and how it can be measured. As Canadian NPP licensees continue to mature and improve this understanding, a more programmatic approach to safety culture is evolving. For licensees, the next stage will be to develop techniques to manage and change safety culture. This requires the development of performance indicators to manage safety culture improvement from current status to new targets that are realistic, but challenging. Management of safety culture involves the alignment of organizational and individual perceptions, beliefs, behaviours, decision making and 'sense of vulnerability' to reach realistic desired safety culture goals. Management can clearly state the priority to safety and assure that visible signs, indicators and rewards are aligned to promoting desired safety culture goals. However, a key component is determining whether the

chosen and expected methods of promoting safety culture improvement are effective throughout the organization and at the individual level.

For the CNSC, the next stage will be to strengthen the regulatory approach to safety culture. In particular the CNSC will further encourage NPPs to develop techniques to manage and foster a healthy safety culture to complement its measurement and tracking. One of the most practical ways to manage individual and shared perceptions, and beliefs, is through coaching and encouraging behaviours, which then may be observed by others and monitored by the regulator. However, individuals will only make the necessary adjustments in behaviour and belief if these are supported by the management at both senior and supervisor levels. Managers and supervisors must also demonstrate through their behaviours and decisions that they place safety at the forefront, that they support a learning organization, and that they expect a questioning attitude and accountability for safety from all.

Another area under development is an approach to addressing nuclear safety culture in new-builds. Although new NPPs are not under construction in Canada, many specification, design and construction decisions will affect the safety of a new NPP once operations commence. Major problems in construction at several plants around the world have alerted the international nuclear community to the impact of organization and safety culture. Vendors, construction companies and licensees will come under increasing pressure to identify how they will improve organizations so that the supply chain delivers nuclear safety to the operators. This aspect is being addressed in the construction licence application guide currently under development.

#### **10 e          Priority to safety at the CNSC**

Due to the nature of its mandate, the CNSC makes nuclear safety the priority in all of its activities. The CNSC's Management System Manual (described in subsection 8.1 d) has clear statements on the consideration of safety in every decision made by the CNSC, and the expectation that organizational and individual behaviours will demonstrate this consideration. In support of this, all regulatory processes within the CNSC Management System are developed respecting the CNSC's focus on safety of staff, licensees and the Canadian public.

The regulatory independence of the CNSC, as described in subsection 8.2, helps CNSC staff maintain its focus on nuclear safety rather than other priorities. The use of risk-informed decision making, described in subsection 8.1 d, also helps CNSC staff systematically consider the many factors that impact risk and safety when making regulatory decisions.

Regarding the safety of CNSC staff, the CNSC is improving its training program by introducing a new course on hazards recognition, which will provide inspectors with broad knowledge to ensure protection of their health and safety when executing their inspection functions.

## **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 facility 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 facility, throughout its life.

### **11.1 Adequacy of Financial Resources**

Each NPP licensee in Canada has the prime responsibility for the safety of its facility. This responsibility includes providing adequate financial resources to support the safety of each NPP throughout its life.

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 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 for capital investments.

Canadian NPP licensees place a high priority on safety-related programs and projects. This ensures that 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**

Canada's four NPP licensees have opted for different methods of supplying decommissioning financial guarantees, as allowed by CNSC regulatory guide *Financial Guarantees for the Decommissioning of Licensed Activities* (G-206). In all four cases, the financial guarantee arrangements include a legal agreement, granting the CNSC access to the guaranteed funds in the event of default by the licensee, as well as licence conditions that require the licensee to revise the decommissioning plans, cost estimates and financial guarantees periodically, or as required by the CNSC. The latter requirements are the means by which 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 development of plans for long-term management of spent fuel under the *Nuclear Fuel Waste Act*.

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 to not renew.

The decommissioning financial guarantees required from Hydro-Québec, NBPN 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. In addition to financial guarantees for decommissioning, the CNSC may also require financial guarantees for other costs where it considers that financial and safety risks warrant such a requirement.

Further details on financial guarantees and decommissioning can be found in Canada's *Third 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 Pickering safe storage project is currently funded by OPG's Operating, Maintenance and Administration budget, some additional capital, and provisional funding from the Ontario Finance Authority (in a ratio of roughly 10, 20 and 70 percent, respectively).

Work is ongoing to finalize the projected scope and annual cost of the work, in order to obtain approval of the Ontario Finance Authority for a fund to support activities after the project is complete.

## **11.2 Adequacy of Human Resources**

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 are characterized by the employment of enough qualified staff to carry out all normal activities without undue stress or delay, including the supervision of work by external contractors.

### **11.2 a Requirements and measures related to training and certification of workers**

#### Licensee Training Programs

Consistent with the CNSC's regulatory philosophy and with international practice, licensees are responsible for the safe operation of their respective NPPs. Consequently, NPP licensees are held entirely responsible for training and testing their workers, to ensure that they are fully qualified to perform the duties of their position.

Training programs are established in accordance to the principles of a systematic approach to training (SAT). Licensee staff members receive training pertinent to their positions, and departmental programs are routinely reviewed. Typically, these reviews result in the revision and development of training needs, courses, and procedures. Criteria to measure training effectiveness are being put in place. This process assures that staff remains competent in their relevant job functions.

Operations and maintenance training is provided to create and maintain job performance capability. This training normally includes classroom instruction, workshops, 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.

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. An industry working group coordinates a joint regulatory affairs training program. Courses on the following topics, developed by individual licensees, the CNSC, and AECL, are shared:

- NPP operating licences
- S-99 reporting requirements for operating NPPs
- the NSCA and its regulations
- introduction to safety analysis
- regulatory issues management
- regulatory communications and technical writing
- INES training

Some of the courses are currently being revised to address the new NPP operating licence format (described in subsection 7.2 (ii) d).

The use of supplemental staff is important to licensee performance of critical work on safety and safety-related systems during maintenance outages. Typically, supplemental workers are recruited to augment outages, but they can also be involved in engineering/design work. Ensuring the supplemental workers are familiar with nuclear-related practices, knowledge and skills has become a significant challenge. The nuclear industry has recognized the need to improve the manner in which licensees provide oversight, supervision and training for the supplemental workforce.

In response to this challenge, the industry developed a supplemental personnel process to improve the safety and efficiency of supplemental workers and supplemental supervisors, with inputs from plant evaluations, peer reviews and benchmarking trips. The supplemental personnel process will be used to identify, select, train, supervise, monitor, release, and assess supplemental personnel (both internal and external). The process will focus on known areas of weakness, such as oversight, use of the work control process, use of the corrective action program, safe work behaviours and the use of human performance tools. The process has been adopted by the Canadian licensees, and its implementation is at different stages at each NPP, based on current work requirements.

#### Qualification and Numbers of Workers

Annex 11.2 a provides the requirements for the qualification and numbers of workers at NPPs, including those for authorized nuclear operators.

In August 2007, the CNSC issued the regulatory guide *Ensuring the Presence of Sufficient Qualified Staff at Class I Nuclear Facilities – Minimum Staff Complement (G-323)*. This guide covers the basis for minimum staff complement, including the validation of minimum staff complement requirements. The CNSC monitors the hours of work violations, the percentage of time operating at minimum complement and the staffing plan (all reported quarterly by the licensees), as well as licensee reports of violations of minimum complement.

#### Transfer of Responsibility for Certification Examinations of Personnel from the CNSC to Licensees

Since 2000, the CNSC has been moving towards a model for personnel certification that is based on the assurance of competence from a system of enhanced regulatory oversight of the licensees' training and examination programs, rather than a CNSC-led examination of certification candidates. This transition is consistent with CNSC regulatory policy *Regulatory Fundamentals (P-299)*, which states that licensees are directly responsible for managing their regulated activities.

In 2008, following industry and stakeholder consultation and the publishing of CNSC document *Certification of Persons Working at Nuclear Power Plants (RD-204)*, all NPP licensees successfully applied to amend their operating licences to incorporate RD-204 and to independently administer initial certification examinations of their shift personnel seeking CNSC certification.

#### Assessment of Licensee Training Programs

CNSC defines and establishes regulatory requirements and criteria for the training, examination and qualification of licensee personnel including certified personnel at NPPs. This includes regularly evaluating licensee training programs for certified and non-certified staff. Regulatory activities include assessment of SAT-based processes and procedures, review of training programs as well as onsite evaluation and inspections of the training program products and material.

The performance of the CNSC program Training, Examination and Certification, under the Performance Assurance safety area, is assessed annually for all licensees in the *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants*. During the reporting period, the licensees had generally satisfactory performance in the Performance Assurance safety area. See Appendix F for a full definition of the CNSC programs and safety areas and the performance ratings of the licensees during the reporting period.

Suggestion S8 from IRRS Mission

*“CNSC should review and continue adopting a consistent process for confirming competence of operators of facilities commensurate with the risks / hazards posed by the facilities.”*

The CNSC will continue to review, and adapt as reasonably practicable, a consistent process for confirming competence of operators of facilities commensurate with the risks/hazards they represent.

Subsequent to the recent regulatory change to authorize NPP licensees to administer certification examinations, CNSC staff will continue to enhance its regulatory oversight of the training and examination of key safety-related personnel at NPPs. This will be achieved by continued verification of the licensees’ programs and processes for the initial and renewal of certification, and by reporting their compliance performance against CNSC regulatory requirements. Upon completing the implementation of this regulatory change, CNSC staff will assess the feasibility of extending this authorization to other licensees of limited personnel resources.

CNSC will continue to certify all persons occupying key safety-related positions at NPPs, non-power reactors and research reactors through a consistent certification process based upon verification of the SAT-based training programs and equitable examination processes.

### 11.2 b Capability maintenance at NPP sites

One of the actions on Canada from the Third Review Meeting was to maintain safety competence in the nuclear industry.

In 2008, the Electricity Sector Council and Human Resources and Social Development Canada conducted a comprehensive study to:

- assess the extent of the labour supply/demand gap
- better understand which areas and occupations are under the most pressure of impending labour shortages, and the types of pressures that exist
- determine appropriate actions to mitigate the effects of potential human infrastructure shortages

The study identified the following key findings for the electricity sector:

- Employment numbers rose to approximately 88,300 — a 10% increase compared to a similar study in 2004.
- Retirement continues to be a serious and impending issue.

- 28.8% of the current electricity workforce is expected to retire between 2007 and 2012, at an annual retirement rate of 6.2%, which is higher than was estimated in the 2004 study.
- Approximately 55% of employees were 55 years and older, compared to 52% in the 2004 study.
- Recruitment and retention continue to be a priority for the electricity sector, to address existing vacancies and upcoming retirements.
- Increasing the supply of trained graduates into the electricity sector will require increased collaboration between industry, employers, and educational institutions.

Expected increases in demand in electricity in provinces across Canada means that provinces will be required to build significant new generation capacity over the next 20 years. The challenge for the electricity sector will be in hiring the workforce to build and operate the new facilities. An additional constraint is that the oil sands development and expansion in western Canada, as well as gas pipeline construction projects, may reduce available labour for the electricity sector.

The nuclear industry in Canada has assessed these challenges and has robust development and worker replacement programs in place to meet future needs. Changes in workforce demographics and the increasing industry HR requirements due to refurbishments and new construction have led to initiatives in four related areas:

- detailed workforce capability analyses
- hiring programs
- training programs for new employees
- knowledge retention programs to capture the knowledge of retiring workers

#### 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.

Succession planning processes are also in place at the NPPs to predict, plan and prepare for replacement of senior-level personnel. Leadership positions down to the level of department manager are identified, and assessments of employee readiness to assume a position (from ‘ready now’ to ‘ready in one to two years’ to ‘ready in three to five years’) are being conducted. Development plans are put in place, to prepare potential candidates to assume critical positions as employees retire.

AECL is addressing this issue through a comprehensive resource management system that focuses on engineering services to NPP licensees, refurbishment of existing reactors, and new reactors to be built. This centrally-managed system covers various groups in AECL business units, and takes an optimal approach to deal with volatility of business, balance customer needs, and ensure a consistent approach while complying with its collective agreement and using best practices. System elements are grouped based on supply, demand, resource planning, development of resources and performance management. Skills of individual technical staff are

identified and maintained in a database, and succession planning specifically targets technical leaders and contractors. The attrition risk of these employees is identified as high, medium or low, with high risk typically covering senior staff members with specialized skills, who are difficult to retain and train. Position descriptions are developed and used as the target for career development and training of staff.

### 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 local community colleges, with which NPP licensees have established partnerships 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 (see “External Training Programs” below).

The NPP licensees are also active in programs such as campus outreach and robotics competitions, as well as in other organizations, such as Women in Nuclear and North American Young Generation in Nuclear, to promote the industry and increase the pool of potential applicants.

At AECL, the supply of staff in the needed skills is maintained by internal postings and external hiring, including that of experienced staff on contract, such as retirees from AECL or the licensee organizations.

### External Training Programs

The University of Ontario Institute of Technology (UOIT) has shaped a nuclear engineering program to specifically meet industry needs. The program has graduated over 100 students since 2007. Industry members and the CNSC participate in formulating the curriculum through involvement in an advisory board to the university. UOIT includes the Faculty of Energy Systems and Nuclear Science, and offers undergraduate (bachelor) degrees and master’s-level graduate courses and graduate diploma programs in nuclear engineering, radiation science, and related areas. A PhD program is in preparation. The programs focuses on reactor kinetics, reactor design, plant design and simulation, radiation detection and measurement, radiation biophysics and dosimetry, environmental effects of radiation, production and utilization of radioisotopes, waste management, fuel cycle, radiation chemistry, and material analysis with radiation techniques. Similar engagements with other colleges are helping to secure skilled labour and operator staffing needs for the future.

The University Network of Excellence in Nuclear Engineering (UNENE) is an alliance of universities (UOIT and others) and NPP licensees, as well as research and regulatory agencies, to support and develop nuclear education and research and development capability in Canadian universities. The main objective of UNENE is to assure a sustainable supply of qualified nuclear engineers and scientists to meet the current and future needs of the Canadian nuclear industry, through university education, university-based training, and the encouragement of young people to choose careers in the nuclear industry. The primary means of achieving this objective has been to establish new nuclear professorships in seven Ontario universities, and to enhance funding for

nuclear research in selected universities, in order to retain and sustain nuclear capability in the universities. Through its member universities, UNENE organizes and delivers educational programs appropriate to students planning to enter the nuclear industry and to those already employed therein.

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 a comprehensive set of Web-accessible education and training documents, with university participation. The CANTEACH program continues to accumulate information contributed by the Canadian nuclear industry, universities and the CNSC.

All NPP licensees and AECL also have internal training programs, focusing on training in CANDU technology and on soft skills, such as behaviour competencies. In addition, AECL provides ongoing seminars on specific topics provided by experienced personnel from AECL, as well as the licensees and academics.

### Knowledge Retention Programs

Various knowledge transfer initiatives are underway to address the potential for critical knowledge loss with the departure of a large segment of the nuclear industry's knowledge workers. For example, OPG piloted a knowledge retention process in engineering. This process focuses on the critical positions, where knowledge loss is the greatest threat, by prioritizing specific skills and knowledge at risk, and developing concrete actionable responses to mitigate the loss. The program's three major activities involve conducting a knowledge loss risk assessment, determining an approach to capture the critical knowledge, and monitoring and evaluating the knowledge retention plan. The knowledge loss risk assessment includes establishing a rating based on the time until retirement or departure, and the position criticality, to determine a total attrition factor. Self-assessments of skills, knowledge and tasks, as well as interviews, are conducted to identify knowledge loss areas and assess the criticality and consequences of the loss. These are prioritized, and options to retain or mitigate the loss are identified. An action plan will include one or more of the following:

- mentoring and coaching staff (including new and existing junior or experienced staff) to transfer knowledge
- hiring new staff: internal or external hiring of junior and experienced employees or contractors
- sharing resources between departments
- codification: documenting processes; listing information and source documents, guides, technical bases; reverse engineering
- training through on-the-job training, rotations, or formal external education
- buying the expertise from consultants, or external design agencies

Skills and knowledge are being retained by hiring experienced contractors to act as mentors to new employees and to train people in skills that are in demand, or at risk of being lost. AECL also has a formal mentorship process for junior staff.

AECL has 'small-scale centres of excellence' that are led by experienced AECL personnel, and focus on retaining high-priority skills. These centres enable current technical leaders to

document their knowledge and experience, and to share it with selected potential technical leaders, through holding seminars and informal discussions and by developing Web sites. Currently, these centres focus on high-priority skills, such as control and safety system concepts, electrical power systems, reactor structures, fuel handling, reactivity mechanisms, feeder and steam generator integrity and fuel channels.

Furthermore, AECL has a Communities of Interest program to preserve, maintain and enhance current working knowledge. The program typically covers activities related to preserving and sharing past and current knowledge, ensuring that standards, manuals and guides are current, developing new standards and manuals, enhancing engineering tools, making engineering and documentation processes more efficient, and improving training methods and materials. Currently, this program exists for equipment engineering, rotating equipment, valves, reactor physics methods, and work processes for process and civil engineering, in addition to one for career development and training plans.

#### Maintaining Research and Development Capability

In addition to the human resource challenges noted above, there has been some concern that available funds for nuclear power research and development (R&D) may be insufficient to sustain the core R&D elements of people and facilities. With the increased emphasis on nuclear electricity generation and refurbishment of reactors, it is important to retain adequate core R&D capability, preserve expert knowledge, and train future experts.

With this in mind, COG produces a report on R&D capability in the Canadian nuclear industry every three years. 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 2009 report assessed the impact of the R&D funding stream during the previous three years (2006–09) and of the resources anticipated for the subsequent three years (2009–11). The 2009 report noted that sustained R&D funding in recent years has allowed the industry to adequately maintain the infrastructure (both facilities and expert staff) needed to support safe and efficient operation of nuclear facilities as they age. Initiatives such as knowledge retention through the production of state-of-the-art reports, code software quality assurance documentation, consolidated databases and operational guidelines, along with higher-level initiatives related to the management of knowledge retention and the elimination of singleton-expertise, are expected to produce positive results in the short and medium terms.

Appendix E describes the R&D programs for Canadian NPPs during the reporting period. 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 significant findings generated by R&D to the CNSC, according to their operating licences, which refer to CNSC document *Reporting Requirements for Operating Nuclear Power Plants* (S-99).

Good Practice G7 from IRRS Mission

*“CNSC’s expectations for scheduled reporting of research and development activities.”*

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Noted as a good practice. This is done to ensure that the CNSC is fully cognizant of licensee research programs, such that the CNSC can input to those programs if they are deemed to be deficient. The CNSC will continue with this practice.



## 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 factors 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 environment in which he/she works, and the training he/she has 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 regulatory policy *Policy on Human Factors* (P119) describes how the CNSC considers human factors during its licensing, compliance, and standards development activities. When determining if NPP license applicants are qualified, and if they have made adequate provision for the health, safety and the environment, the CNSC will evaluate the extent to which the applicant has considered human factors and applied that knowledge, and the acceptability of their programs they plan to use for this purpose.

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

- *Human Factors Engineering Program Plans* (G-276)
- *Human Factors Verification and Validation Plans* (G-278)
- *Ensuring the Presence of Sufficient Qualified Staff at Class I Nuclear Facilities - Minimum Staff Complement* (G-323)
- *Design of New Nuclear Power Plants* (RD-337)
- *Life Extension of Nuclear Power Plants* (RD-360)
- *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* (S-294)
- *Safety Analysis for Nuclear Power Plants* (RD-310)

Human factors engineering (HFE) is the application of knowledge about human capabilities and limitations to plant, system, and equipment design. Human factors engineering ensures that the design, human tasks and work environment are compatible with the sensory, perceptual, cognitive, and physical attributes of the personnel who operate, maintain, and support it. In the Canadian nuclear industry, HFE principles are included in modifications to existing NPPs, for life extensions, and for new-builds. HFE effort increases with higher levels of interface complexity or criticality, and more HFE effort is typically required for operator tasks.

Human Factors is one of the three programs under the CNSC's Performance Assurance safety area, and is assessed annually for all licensees in the *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants*. During the reporting period, all the licensees had satisfactory performance in the Performance Assurance safety area (with a single exception in 2007). See Appendix F for a full definition of the CNSC programs and safety areas (Table F.1), and the performance ratings of the licensees during the reporting period (Table F.2).

In the next reporting period, CNSC staff will continue to develop human factors requirements for new-build construction licence reviews. In addition, issues related to human and organizational factors will be considered for NPPs that are approaching their end of life, but not refurbishing.

The CNSC subdivides its assessment of the Human Factors program into the following specific technical review areas, which are described in the following subsections:

- human performance programs
- human factors in design
- human actions in safety analysis
- procedures
- work organization and job design
- fitness for duty
- organizational performance
- performance monitoring and improvement

### **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 is influenced by the various aspects of human factors. Good human performance is supported by good hardware and software design, high-quality procedures, good procedural adherence, effective work organization and careful job design. It is also necessary to ensure that workers are fit for duty and are supported by appropriate organizational mechanisms, continuous monitoring, and an organizational commitment to improvement.

A human performance improvement program for a licensed facility encourages assessment of internal and external events and operating experience (OPEX) as opportunities to address problems before errors occur. Detailed reviews of operational conditions, activities, incidents, events (e.g., review of station condition records) are conducted by all NPP licensees, to facilitate the detection and correction of human performance issues (see subsection 19 (vii) for more information).

NPP licensees strive to maintain learning environments to identify and resolve all issues related to human errors. In keeping with a learning environment, licensees also 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 licensee organizations assign responsibilities and accountabilities for human performance and minimize errors are described in Annex 12 a.

CNSC staff's review of human performance programs focuses on ensuring that licensee programs are comprehensive, include strategies, policies, processes, and practices that support excellence in human performance, have defences that prevent and mitigate the consequences of human error, and are implemented effectively.

Human performance programs for a facility 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 of nuclear facilities.

Canadian NPPs all have human performance programs, but these can be considered to have evolved to different levels of maturity. Currently, the human performance programs are focused largely on monitoring individual behaviours and the use of event free tools. There is a concentration on assessing procedural adherence, coaching better attention etc. CNSC recognizes the benefit of licensees encouraging employees to get more involved in devising methods to improve the quality, and reliability of their work, while more fully appreciating its importance to nuclear safety.

CNSC staff is working with licensees to expand the approach to address human performance at an organizational level. In addition, there is a need to develop stronger links between other programs and the human performance program, leading to a more integrated approach to human performance.

CNSC staff is also investigating useful leading indicators of human performance that accurately reflect safety performance, rather than relying on lagging indicators (such as event-free days).

The requirement for a licensee to have a documented human performance program will be included as a licence condition when NPP operating licences are renewed, starting in 2010.

## **12 b Human factors in design**

The consideration of human factors in design applies to the design of new facilities, and to the modification and decommissioning of existing facilities. Human factors in design is concerned with ensuring that the design or modification of facilities, systems, and equipment integrates information about human characteristics, performance, and limitations to ensure safe and reliable task and system performance, and to minimize the potential for human error. It considers the cognitive, physical and sensory characteristics of people who operate, maintain or support the system, so that the systems and equipment are designed to support human performance.

The CNSC document *Life Extension of Nuclear Power Plants* (RD-360) describes the regulatory expectations that must be addressed at the start of a life extension project. Through this work, licensees must determine the extent to which the current plant and plant performance conform to modern standards and practices, identify any gaps between the current plant status and modern standards, and identify any factors that would limit safe long-term operation. During the reporting period, CNSC staff worked with licensees undergoing life extension projects, to ensure that the human factors reviews against modern standards met these expectations.

The CNSC issued document *Design of New Nuclear Power Plant (RD-337)* during the reporting period. RD-337 includes requirements for addressing human factors in the design of new NPPs. See subsection 18 (iii) for details.

A description of how the Canadian nuclear industry considers human factors through its application of HFE is provided in Annex 12 b.

CNSC staff's review of human factors in design focuses on ensuring 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 also focuses on ensuring that the human factors in design process is implemented effectively by suitably trained, qualified, and competent human factors specialists.

### **12 c 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. Human reliability analysis is a method to estimate the probability that a system-required human action, task, or job required 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. More information on PSA is provided in subsection 14 (i) b.

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 obtain more comprehensive estimates of probability of system performance, incorporating the probability of human errors in critical sequences. CNSC staff's review of human actions has focused on the execution of control room and field components of emergency operating procedures. Through observation of validation work, CNSC staff has been able to ensure that the factors that impact human performance in the completion of the emergency operating procedures have been considered and that the human actions are achievable.

### **12 d Procedures**

Operations (both normal and abnormal) and maintenance procedures provide detailed instructions for completing assigned tasks. Procedural accuracy and compliance minimize the possibility of human errors. Procedures must be technically accurate, comprehensive, clear, concise, and contain adequate information and direction for the staff (e.g., operators, maintainers or testers) to complete their tasks. This ensures that the procedures are fit for purpose. To accomplish this, the licensee should use information from task analyses to develop the various technical steps in the procedure, and the format and organization of procedures should be based on a writer's guide that considers usability of the procedures. The licensee should also show how it validates procedures, by conducting walkthroughs of the tasks with representative end-users, in

order to ensure that the procedures can be conducted as intended, and that the technical requirements of the tasks can be achieved.

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

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

### **12 e Work organization and job design**

Work organization and job design relates to the organization and provision of adequate staff, and the organization and allocation of work assigned to staff, in order to ensure that work-related goals are achieved in a safe manner. It includes, but may not be limited to, staffing levels and minimum shift complement.

The minimum shift complement is the identified number of staff with specific qualifications that must be present at the station at all times to carry out the licensed activity safely and in accordance with the NSCA, the regulations and the licence. The numbers and qualifications of staff must be adequate to respond to the most resource-intensive conditions under all operating states. CNSC document *Ensuring the Presence of Sufficient Qualified Staff at Class I Nuclear Facilities - Minimum Staff Complement (G-323)* describes CNSC staff's expectations of the key factors that must be considered for ensuring the presence of a sufficient number of qualified staff at Class I nuclear facilities.

Projects are currently underway at two NPPs to analyze the minimum shift complement staffing numbers, using the expectations set out in G-323. Similar projects to analyze the minimum shift complement staffing numbers will be initiated for the other NPPs in the next reporting period.

Plant staffing levels and hours of work can be severely tested during periods of widespread illness. In response to the H1N1 pandemic, the CNSC required all licensees to submit pandemic preparedness plans. A review of the plans confirmed that provisions and measures to ensure the maintenance of minimum shift complement have been put in place by all licensees.

### **12 f Fitness for duty**

Fitness for duty is a broad topic that touches on occupational health, physical and mental ability, the use of potentially physio- and psycho-active substances, and occupational fitness. Fitness for duty is defined as a condition in which workers are physically, physiologically, and psychologically/mentally capable of performing the tasks of their assigned jobs within the required standards of safety, attendance, quality, efficiency and behaviour.

In order to ensure that workers possess the minimum requirements to perform their job safely, and minimize the risks to plant safety, the environment, or harm to themselves or others, NPP licensees conduct various evaluations. Depending on the risks associated with a position, these

may include medical evaluations, physiological evaluations, mental or psychological evaluations, biochemical or substance testing, occupational or physical fitness, and behavioural or performance evaluations. These evaluations are conducted in various circumstances, including pre-placement, periodic, return-to-work, employee health assistance program, and continuing disability.

Following the publication of CNSC document *Certification of Persons Working at Nuclear Power Plants* (RD-204), CNSC staff initiated a project to further define requirements and applicability of fitness-for-duty programs. CNSC staff has gathered information from comparable high-risk organizations, non-Canadian regulators and current NPP licensee programs relating to fitness for duty. In the next reporting period, the CNSC will consult with stakeholders, develop a proposal to establish a regulatory position on fitness for duty, and oversee the beginning of implementation at NPPs.

### **12 g Organizational performance**

The organizational performance review area considers the influence of organizational structures, roles and responsibilities, communications, and other team processes, and policies on safety performance at Canadian nuclear facilities. For example, safety performance 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 individual line staff that carry out the operational work tasks.

CNSC staff's review of organizational performance focuses on ensuring that safety functions and safety culture influences on human performance, such as structures, policies, and processes, support the safe conduct of the nuclear activity. Organizational performance is monitored and assessed through a number of activities, such as desktop reviews, regulatory inspections, and licensee self-assessments.

CNSC assessment of licensees' organizational performance is described more fully in subsection 10 c.

### **12 h Performance monitoring and improvement**

Performance monitoring and improvement applies throughout the entire lifecycle of the nuclear facility. The CNSC staff's review of performance monitoring and improvement focuses on ensuring that there is a systematic, objective and comprehensive process for monitoring and improving safety. This includes effective processes to learn from operating experience and to identify and trend events and near misses (see subsection 19 (vii) for details on licensees' programs in this area). Human actions contribute to the majority of events; therefore, it is important that apparent cause evaluation or root cause analysis techniques include the identification of human and organizational factors that may have contributed to the event. The CNSC staff review also focuses on ensuring that corrective action plans are systematically developed, comprehensive, and effective for addressing the causes of an event.

Licensees have developed coding schemes to identify the causes of adverse conditions. Adequate and consistent use of human and organizational performance codes applied to the causes of events is essential to ensure that the trending and identification of adverse conditions is effective.





## 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 operating life of a nuclear installation.

### 13 a Implementation of management system/quality assurance programs

The *Class I Nuclear Facilities Regulations* require licensees to implement quality assurance (QA) programs during the following phases of the NPP lifecycle:

- siting
- construction
- operation (maintenance, modification)
- decommissioning

Applications to prepare a site and to construct an NPP must also include the proposed QA program for the design of the NPP.

During the reporting period, except as noted below, the NPP operating licences specified the old CSA-N286 series of standards as the regulatory requirement for power reactor QA programs.

The CSA-N286 series includes the following standards:

- *Overall Quality Assurance Program Requirements for Nuclear Power Plants* (N286.0)
- *Procurement Quality Assurance for Nuclear Power Plants* (N286.1)
- *Design Quality Assurance for Nuclear Power Plants* (N286.2)
- *Construction Quality Assurance for Nuclear Power Plants* (N286.3)
- *Commissioning Quality Assurance for Nuclear Power Plants* (N286.4)
- *Operations Quality Assurance for Nuclear Power Plants* (N286.5)
- *Quality Assurance of Analytical, Scientific and Design Computer Programs for Nuclear Power Plants* (N286.7)

The requirements of the CSA-N286 series apply to safety-related systems, which are defined in Annex 13 a. Licensees are required to identify the safety-related items, activities and processes in accordance with the definition, and the CNSC reviews them for acceptance.

During the reporting period, the transition continued as planned from the old CSA N286 series of standards for power reactor QA programs, to the new CSA standard *Management System Requirements for Nuclear Power Plants* (CSA N286-05). CSA-N286-05 was published in 2005, and updated in 2007. It describes a broader set of management system requirements than the old N286 series. A primary purpose of the new standard is to promote safe and reliable operation of NPPs, with a focus on management's role in controlling and managing work processes. It states that safe and reliable NPPs require commitment and adherence to a set of management system principles and, consistent with these principles, the implementation of a planned and systematic

pattern of actions that achieves the expected results. The principles, the required supporting actions, and the documentation that describes them constitute the management system.

The 14 management system principles in CSA N286-05 are as follows:

1. The business is defined, planned and controlled.
2. The organization is defined and understood.
3. Personnel are competent at the work they do.
4. Personnel know what is expected of them.
5. Work is planned.
6. Experience is sought, shared and used.
7. Information is provided in time to the people who need it.
8. The performance of work is controlled.
9. The preparation and distribution of documents is controlled.
10. Work is verified to confirm it is correct.
11. Problems are identified and resolved.
12. Changes are controlled.
13. Records are maintained.
14. Assessments are performed.

The management system principles are the basis of all the generic requirements in CSA N286-05, which apply to all work activities, as well as a large cross-section of the set of 30 specific requirements. The standard also has supplementary requirements contained in the annexes that are related to design, purchasing and material management, construction and installation, commissioning, decommissioning, and verification of work.

CSA-N286-05 specifies general requirements for the conduct, independence, frequency, scope, and timing of the licensee's audits of its management system. Audit results must be reported to, and assessed by, a level of management with sufficient responsibility to ensure that audit findings are addressed. For operating facilities, in addition to the required self-assessments and independent assessments, the plant management team must conduct a formal review of the management system's effectiveness.

The Bruce A and B operating licences, renewed during the reporting period, were the first to reference CSA N286-05. The Bruce Power Management System is described in Annex 13 a.

During the reporting period, the other licensees continued to align their management systems with CSA N286-05. By the end of 2011, all NPP operating licences will reference CSA N286-05. Life extension projects and new NPP applications also require adherence to CSA N286-05 requirements..

The management system and QA requirements are binding on all personnel whose work can affect nuclear safety. This includes the work performed by organizations that are not part of the licensee's organization. When a licensee has to rely on other organizations to carry out work, the licensee must ensure that management system and QA requirements are passed on to these organizations and are met. As the work progresses, the licensee will conduct real-time reviews,

audits, and inspections to make sure that the work meets the requirements. Frequency is determined by factors such as safety significance and the performance of the organization.

Approved suppliers lists are used by Canadian NPP licensees, in line with the old CSA standard N286.1 (as well as CSA N286-05). Canadian licensees ensure that all external organizations that are performing work that can affect nuclear safety have a QA program and a corresponding certificate. Licensee procurement and vendor QA specialists obtain copies of the certificate and program manuals and assess them against the relevant Canadian nuclear standards. Also, as members of industry groups, Canadian licensees can audit external organizations or have them audited by a third party. For example, Canadian licensees are members of the CANDU Procurement Audit Committee and the Nuclear Procurement Issues Committee (North American), which provide a cost- and quality-effective program for evaluating suppliers that furnish nuclear safety-related items and services. Licensees have access to previous audit reports to measure an organization's adherence to its QA standard and to compare it against Canadian requirements. If some requirements are not reflected in programs of the external organization, a corrective action is raised requesting programs to be altered accordingly.

### **13 b      CNSC assessment of licensees' management system/quality assurance programs**

Separate from the internal reviews and audits carried out by the licensees, the CNSC conducts detailed reviews of the documentation that communicates management system requirements to licensee personnel. When it is accepted, the CNSC carries out real-time audits to make sure that the licensee and other organizations are complying with the requirements. These performance-based audits assess the following activities of the licensee during each particular phase of work for the facility, to make sure that safety is of the highest priority:

- work methods
- management processes and results
- overall compliance

The performance of the CNSC Quality Management program under the Performance Assurance safety area is assessed annually for all licensees in the *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants*. During the reporting period, all the licensees had satisfactory performance in the Performance Assurance safety area (with a single exception in 2007). The performance of the CNSC Organization and Plant Management program under the Operating Performance safety area is also assessed annually for all licensees in the *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants*. During the reporting period, all the licensees also had satisfactory performance in the Operating Performance safety area (with a single exception in 2007). See Appendix F for a full definition of the CNSC programs and safety areas (Table F.1) and the performance ratings of the licensees during the reporting period (Table F.2).

The third and fourth Canadian reports described the licensees' progress in implementing measures of QA programs for pressure-boundary work. An update on this issue is provided in Annex 13 b.

**13 c      Development and transition to management system requirements**

CNSC staff continues to participate in, and promote, the development of integrated management system requirements that are aligned with the IAEA safety standard *The Management System for Facilities and Activities* (GS-R-3). The draft CSA standard *Management System Requirements for Nuclear Facilities and Activities* (CSA N286-11) will be available for licensee and public review in 2010, with an anticipated publication date in 2012. CSA N286-11 will be applicable to licensees of Class IA facilities, as well as class IB facilities and uranium mines and mills.

It is expected that new integrated management system requirements will be gradually implemented over a few years. Future assessments of licensees against these new integrated management system requirements will: focus on overall safety performance; examine the links between human performance, safety management, safety culture and the management system; and involve assessments, along with other key processes, of the management of organizational change, risk management, continuous improvement and resource management. This would integrate the assessment of provisions described in this Article, as well as in Articles 10, 11, and 12.

## 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

#### CNSC Assessment of Licensee Programs Associated with Safety Analysis

The performance of the CNSC Safety Analysis program under the Design and Analysis safety area is assessed annually for all licensees in the *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants*. During the reporting period, all the licensees had satisfactory performance under the Design and Analysis safety area. See Appendix F for a full definition of the CNSC programs and safety areas (Table F.1) and the performance ratings of the licensees during the reporting period (Table F.2).

#### CANDU Safety Issues

Comprehensive provisions for assessment and verification of safety for Canadian NPPs have served to confirm the ongoing safety of operating NPPs in Canada. As part of this process, they have led to the identification and resolution of safety issues, some of which have been described in previous Canadian reports. In recent years, it was recognized that a more systematic approach to identifying, prioritizing, and resolving safety issues would optimize the improvements to safety that would be realized by these efforts.

During the reporting period, the CNSC and industry collaborated on a project to survey generic safety issues related to CANDU reactors, rank them, and evaluate strategies to address them in a risk-informed manner. The safety issues 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 are issues that have been satisfactorily addressed in Canada.
- Category 2 are 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 need 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, immediate safety significance are addressed by other means on a priority basis (see subsections 7.2 (iii) and (iv)).

A risk informed decision making (RIDM) process (see subsection 8.1 d) was applied to the potentially risk-significant issues (Category 3) to identify, estimate and evaluate the risks associated with each of them, 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 on the workers, the public or the environment, or any combination thereof.

A more detailed description of the identification and categorization of the CANDU safety issues and the activities being undertaken to control the risks associated with some of the Category 3 issues is provided in Appendix G.

The CNSC will maintain regulatory control of the resolution of the significant safety issues, by monitoring the path forward established through mutual agreement between the CNSC and the industry.

The list of CANDU safety issues that were surveyed included those that were being addressed by generic action items (GAI). GAIs have been used as a regulatory tool to define the scope of certain safety issues, identify technical concerns, specify requirements for their resolution, and monitor the progress. Most of the safety issues covered by the GAIs are now covered by the CANDU safety issues; those not covered are near resolution (subsection G.4 in Appendix G provides more details).

Challenge C-4 for Canada from the Fourth Review Meeting  
*“Establish and pursue a success path for Large LOCA safety margin”*

Issues associated with positive void reactivity and safety margins for large-break loss of coolant accidents (LBLOCA) in CANDU reactors were the subject of some of the GAIs. These issues are now being addressed as Category 3 CANDU safety issues. See subsection G.2 in Appendix G for details on how issues related to LBLOCA are being systematically resolved.

#### **14 (i) a Deterministic safety analysis**

Paragraph 5(f) of the *Class I Nuclear Facilities Regulation* requires an applicant for a construction licence to submit a preliminary safety analysis report. The preliminary safety analysis report must include the deterministic safety analysis, a probabilistic safety assessment (PSA), and a hazards analysis. The following additional paragraphs in the *Class I Nuclear Facilities Regulation* specify supporting design information that must also be submitted:

- Paragraph 5 (a): 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 (b): a description of the environmental baseline characteristics of the site and the surrounding area

- Paragraph 5 (d): a description of the structures proposed to be built as part of the nuclear facility, including their design and their design characteristics
- Paragraph 5 (e): 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 (g): the proposed QA program for the design of the nuclear facility

Under paragraphs 6(a) and 6(b) of the same regulation, an application for a licence to operate an NPP 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 NPP. Details on the content of a typical safety analysis report are provided in Annex 14 (i) a.

The tools and methodologies used in licensees' safety analysis reports are proven according to national and international experience, and validated against relevant test data and benchmark solutions. In addition to the QA requirements for safety analysis specified in paragraph 5(g) of the *Class I Nuclear Facilities Regulations*, all operating NPPs are subject to CSA document *Quality Assurance of Analytical, Scientific and Design Computer Programs for Nuclear Power Plants* (N286.7), which is cited in all NPP operating licences in Canada.

To meet the operating licence requirement that cites CNSC document *Reporting Requirements for Operating Nuclear Power Plants* (S-99), a licensee shall, within three years of the date of the last submission of the NPP description and final safety analysis report, unless otherwise approved in writing by the Commission Tribunal, submit a report that consists of an updated NPP description and an updated final safety analysis. This report shall include the following information:

- a description of the changes made to the site, structures, systems and components (SSCs) of the NPP, 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 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 S-99

CNSC staff reviews the safety analysis reports when they are submitted. During the reporting period, the licensees' safety analyses, as described in the safety analysis reports, demonstrated acceptable safety margins for all Canadian NPPs.

#### Safety Analysis Methods and Acceptance Criteria for Operating NPPs

In the mid-1960s, a set of siting criteria was developed for assessing the acceptability of NPPs (see Table 6.1 in the second Canadian report for details). Such criteria specified offsite dose limits to be used in safety analyses of any serious process failure (single failure); and any combination of a serious process failure and failure of a special safety system (dual failure). Special safety systems are defined in subsection 18 (i). The criteria are as follows:

- Radioactive releases due to normal operation, including process failures other than serious failures, shall be such that the dose to any individual member of the public

affected by the effluents from all sources shall not exceed one-tenth of the allowable dose to nuclear energy workers.

- The effectiveness of the safety systems shall be such that for any serious process failure:
  - the exposure of any individual of the population shall not exceed 5 mSv
  - the exposure of the population at risk shall not exceed 100 person-Sv
- For any postulated combination of a (single) process failure and failure of a safety system (dual failure), the predicted dose to any individual shall not exceed 250 mSv to the whole body or 2.5 Sv to the thyroid.

These criteria continue to be used as part of the licensing basis for all Canadian NPPs, except for the Darlington NPP. For the licensing of Darlington, the CNSC consultative regulatory document *Requirements for the Safety Analysis of CANDU Nuclear Power Plants (C-006)* was used on a trial basis. This document addressed deficiencies in the basic single/dual-failure safety analysis requirements, and reflected Canadian experience in applying the single/dual-failure analysis approach.

The safety analysis requirements proposed in C-006 differed from previous practice in the following respects:

- a requirement was introduced for a systematic review to identify postulated initiating events
- five event-classes replaced the two categories of single and dual failure
- combinations of postulated initiating events with failures of mitigating systems (not just the classical dual failures) were explicitly required to be considered
- more sensitivity and error analyses were required

#### Updating Safety Analysis Methods and Acceptance Criteria

During the reporting period, the CNSC continued to update the regulatory framework for NPPs, as described in subsection 7.2 (i) b and subsection 7.2 (i) c. Some of the CNSC documents that contain updated requirements related to design and safety analysis include:

- *Site Evaluation for New Nuclear Power Plants* (RD 346; see Article 17)
- *Design of New Nuclear Power Plants* (RD-337, which includes requirements for integrating safety analysis into the design; see Article 18)
- *Life extension of Nuclear Power Plants* (RD-360)
- *Safety Analysis for Nuclear Power Plants* (RD-310, which is discussed below)

The implementation of these and other documents will enable the CNSC and stakeholders to take into account:

- modern practices in safety analysis
- aging of equipment
- refurbishment
- analytical requirements for new-build and their adaptation to existing NPPs

The licensees are currently working towards updating their safety analyses and safety analysis reports for their NPPs, such that they will be aligned with the new documents. The implementation for operating plants consists of a gap assessment to prioritize analysis activities,



in order to address identified gaps and shortcomings. The most significant issues will be addressed on a priority basis. In the longer term, compliance with these documents, to the extent practicable, will be achieved as part of reactor refurbishment plans. For plants undertaking refurbishment to extend their life, CNSC document *Life extension of Nuclear Power Plants* (RD-360) requires the safety analysis update to be completed to modern standards for a post-refurbished NPP.

The key new document related to safety analysis, RD-310, was issued during the reporting period following extensive consultations with the industry and other stakeholders. RD-310, which is aligned with international standards on safety analysis, identifies high-level regulatory requirements for a NPP licence applicant's preparation and presentation of a safety analysis. The purpose of RD-310 is to update and improve transparency and consistency of safety analysis activities supporting the safe operation of Canadian NPPs.

All NPPs in Canada have been notified by the CNSC to plan for implementation of RD-310, which is expected to be phased in over a number of years. The CNSC has advised the licensees that implementation of RD-310 should be consistent across the industry. Operating licences that are renewed in the next reporting period will have a requirement for a plan to implement RD-310. All new-build will be expected to be fully compliant with RD-310.

In response to this, the NPP licensees established a safety analysis improvement program through the CANDU Owners Group (COG), to address specific safety analysis shortcomings identified by the CNSC as well as other safety analysis issues important to the industry. Although it was recognized that the existing safety cases are not in question, the safety margins and degree of conservatism in the analyses need to be confirmed. One of the purposes of the safety analysis improvement program is to facilitate the implementation of RD-310. Specific areas of focus in the program include the impact of aging on the heat transport system, and evaluating the conservatism and correcting inconsistencies in the safety analyses. The main activities include:

- production of a principles and guideline document for safety analysis
- pilot studies of Darlington loss of reactivity control and Bruce A loss of flow
- gap assessments for the set of analyses in the safety analysis report, followed by the necessary actions to disposition such gaps
- overall improvement of the safety analysis report

The selection of activities undertaken in the safety analysis improvement program is influenced by the CANDU safety issues project, described above and in Appendix G. The output of the program is thus expected to help address the CANDU safety issues. For example, the program addresses the impact of the aging of the heat transport system on a loss of reactor regulation event, which is one of the non-LBLOCA Category 3 CANDU safety issues, described in subsection G.3 of Appendix G.

NPP licensees have established specific validation programs for industry standard tool (safety analysis) codes to provide the necessary confidence in the analytical results. However, validation of data, models and codes used in accident analysis has been identified as a Category 3 CANDU Safety Issue (see subsection G.3 of Appendix G). During the reporting period, the industry

continued to make progress on extending the validation of these codes to all applications. CNSC staff continued to review the existing validation work on some of the principle computer codes and to monitor the implementation of the validation process established by the industry.

#### Fire Hazard Assessment and Fire Safe Shutdown Analyses

A new edition of the CSA document *Fire Protection for CANDU Nuclear Power Plants* (N293) was published in 2007. During the reporting period, the new edition was incorporated into some of the operating licences; the others still refer to the 1995 edition of the standard. The NPP licensees are either in the midst of, or are initiating projects to, perform code compliance reviews (gap analysis) and to revise their facilities' fire hazard assessment and fire safe shutdown analyses. These analyses are being performed using modern methodologies, to evaluate the level of fire protection, while taking into consideration current knowledge and industry best practices.

#### **14 (i) b Probabilistic safety assessments**

Probabilistic safety assessments (PSA) are used for three broad purposes:

- to assess existing and new-build designs to help identify the key plant vulnerabilities, such as to confirm that the level of defence-in-depth is sufficient and the plants meet the safety goals
- to assess the impact of design and operational changes
- to provide input to the RIDM process (see subsection 8.1 d)

All NPP operating licences, except for Pickering A, have a requirement to conduct PSAs according to CNSC document *Probabilistic Safety Assessment for Nuclear Power Plants* (S-294). This document will also be cited in the Pickering A licence when it is renewed in the next reporting period.

The licensees are required to develop, periodically review and update their PSAs, as necessary, in conjunction with the deterministic safety analysis. Annex 14 (i) b reviews the status of the PSAs at each Canadian NPP.

The PSAs, their methodologies and their updates are reviewed by CNSC staff using well-accepted international guidance, to ensure compliance with the requirements in S-294. During the reporting period, insights from the PSAs were considered by CNSC staff to assess the degree to which the operation of the NPPs continues to meet the safety goals. The results of the PSAs and the CNSC reviews indicated that the safety goals were met.

Licensees are at various stages of using the results from their PSAs. Typical applications include their use in conjunction with deterministic analytical results to refine programs for reliability and maintenance. For example, PSA results are used to help identify the 'systems important to safety' for the reliability program (see section 19 (iii)).

Some recent developments indicate a growing use of PSAs for risk monitoring. For example, Point Lepreau is conducting a project for online risk monitoring for use in operational decisions. It has completed industry benchmarking of similar risk monitoring tools, while training and software development continue. Similarly, the most recent revision of the Darlington PSA was used to develop a computerized tool that is routinely used to monitor risk, using severe core

damage frequency, for both outages and full power operation. The PSA will continue to be used to enhance operational risk monitoring programs, and will also provide input to plant refurbishment decisions.

The PSA results are also used in developing severe accident management guidelines (SAMG, discussed in subsection 19 (iv)) or providing insights into the refurbishment process. For the Point Lepreau and Bruce A refurbishment projects, PSA results were used to help establish the refurbishment scope and plant safety improvements. See subsection 14 (i) c for more information on refurbishment projects, and Annex 14 (i) c for examples of design changes that were implemented to help address issues identified through PSA.

**14 (i) c Life extension projects: safety improvements and application of periodic safety review**

Good Practice G-4 for Canada from the Fourth Review Meeting  
*“Conduct of the integrated safety review (which is similar to PSR approach) to decide on the scope of safety improvements, supporting refurbishment of nuclear reactors”*

Challenge C-1 for Canada from the Fourth Review Meeting  
*“Continue the refurbishment activities”*

The CNSC document *Life Extension of Nuclear Power Plants* (RD-360) was issued during the reporting period. It provides guidance on the conduct of refurbishment projects in order to meet regulatory requirements, and describes integrated safety reviews (ISR) and the corresponding integrated implementation plan. See Article 7.2 (i) b for more details on RD-360.

In accordance with RD-360, licensees that are planning life extensions are required to carry out an ISR based on the IAEA periodic safety review (PSR) guide (NS-G-2.10). An ISR is a comprehensive assessment of plant design, condition and operation. It is referred to as an ISR due to its one-time application of a PSR to a life extension project. An ISR provides an overall view of plant safety, and enables the licensee to determine reasonable and practical modifications to enhance the safety of the facility to a level approaching that of modern plants, and to facilitate long-term operation. Operating experience in Canada and around the world, new knowledge from research and development activities, and advances in technology, are all taken into account.

A major part of the assessment is to determine the condition of safety-related structures, systems, and components. This condition assessment, which includes inspections and analysis, will determine the extent to which some components require replacement. For a component that will not be replaced, the assessment is used to update or develop lifecycle management plans that will monitor the component condition, to ensure that it continues to meet its design function.

The safety factors to be addressed in an ISR are listed in the IAEA PSR safety guide NS-G-2.10. In addition, the scope of an ISR should address the CNSC’s safety areas and programs used in

the regulation of NPPs (see Appendix F). Table 3.14.1 of the third Canadian report provides a description of the alignment between the PSR safety factors and CNSC safety areas and programs. An ISR should also address all CANDU safety issues and station-specific action items, with each being resolved to the extent practicable.

At the end of the reporting period, CNSC staff issued documents related to staff review procedures to ensure a consistent and transparent approach for the regulatory oversight of NPPs reaching their end of life/assumed design life. A process, procedure, and review instructions were developed for integrated technical assessments of licensee's ISR submissions. Staff review procedures are described in more detail in subsection 7.2 (ii) a and subsection 8.1 d.

NPP licences are amended to introduce specific licence conditions for the regulatory control of life extension projects. Approval for a reactor's return-to-service is contingent upon the licensee's demonstration that all relevant licence conditions have been met.

#### Bruce A Refurbishment

Refurbishment of Units 1 and 2 for life extension and continued operation was initiated during the reporting period. Major work items undertaken include:

- replacing reactor components such as the steam generators, feeder pipes, calandria tubes and fuel channels
- turbine generator overhauls
- replacing feedwater heaters and condenser tubes
- construction of a secondary control area
- electrical distribution system upgrades and maintenance

Bruce Power is conducting its refurbishment of Units 1 and 2 at Bruce A, under the guidance of CNSC regulatory document RD-360. Bruce Power completed a thorough evaluation of safety and issued an ISR.

#### Point Lepreau Refurbishment

Refurbishment of Point Lepreau for life extension and continued operation was initiated during the reporting period. Major work items undertaken include:

- Reactor was shutdown, defueled, and systems placed in their lay-up state.
- All inlet and outlet feeder pipes and fuel channels were removed, and the retube waste has been transported to, and stored in, the onsite Radioactive Waste Management Facility.
- Various inspections and cleaning were completed, and calandria tube installation is in progress.
- Upper feeder installation is progressing.

In addition to the retube activities, various station upgrades have also been completed that will improve safety and are in various stages of commissioning. Some of these upgrades are listed in Annex 14 (i) c, for illustration purposes.

### Pickering B Refurbishment Feasibility Study and Decision

During the reporting period, OPG completed its study of the feasibility of refurbishing Pickering B using, in part, information from the conduct of an ISR. OPG requested the IAEA to review the ISR process and the completeness and comprehensiveness of the ISR report against IAEA safety guide NS-G-2.10 and other IAEA safety standards. The IAEA review concluded that the ISR for Pickering B was in full accordance with NS-G-2.10 and that it systematically assessed the extension of the station operation beyond the predicted end of service and identified the measures necessary for refurbishment.

In 2010, OPG announced that Pickering B would not be refurbished but would, instead, enter its final decade of operation. Since the four units are approaching the end of their assumed design lives, OPG was requested to prepare an end-of-life operation plan for Pickering B. In parallel, and as part of its regulatory framework, CNSC has drafted expectations for operating an NPP beyond its assumed design life. Such expectations are currently being considered as input into a revision to CNSC document RD-360. For the continued operation of Pickering B beyond the assumed design life, OPG is expected to include in its end-of-life operation plan:

- specifications on end-of-design life and end-of-operating-life for each unit
- information on condition assessments and demonstration of plant fitness for service
- a list of safety improvements that would be implemented based on the condition assessments
- information on safe storage of fuel, preliminary decommissioning plan, and preliminary site restoration plan

The ISR for Pickering B will provide valuable input into its end-of-life operation plan.

#### **14 (i) d Consideration of periodic safety reviews for operating reactors**

Challenge C-5 for Canada from the Fourth Review Meeting  
*“Continue discussions on possible implementation of PSR”*

Previous Canadian reports noted that, as part of the operating licence renewal process for NPPs, the CNSC and the licensees already perform safety assessments similar in nature and intent to the PSR described in IAEA documentation. Furthermore, as mentioned above, the third Canadian report mapped the IAEA PSR safety factors (from NS-G-2.10) against the Canadian licensing and refurbishment requirements, and concluded that the approaches are aligned.

The consideration of PSR for NPPs is the lead activity in a broader CNSC initiative to consider implementing PSR for all Class I facilities in Canada.

During the reporting period, CNSC staff, in consultation with NPP licensees, continued to evaluate the implications of formally incorporating PSR in the Canadian regulatory process for NPP licensing. The lessons learned through the application of ISR to NPP refurbishment projects were important considerations. It was concluded that adopting the IAEA PSR methodology would result in some benefits with respect to, *inter alia*, regulatory oversight of NPPs; this conclusion was further corroborated by other countries' experience with applying PSR, by

consultations in national and international fora, and by a detailed study conducted by a consultant.

During the reporting period, several key initiatives were completed that will facilitate the implementation of PSR if the decision is made to proceed. Those initiatives include the:

- definition of the licensing basis (see subsection 7.2 (ii) a)
- licence improvement project (new licence format and introduction of the licence condition handbook, as described in subsection 7.2 (ii) d)
- increased application of risk-informed decision making (RIDM, as described in subsection 8.1 d)
- development and maturation of licensees' management systems (see subsection 13 b)

A decision related to the use of PSR must consider factors such as the frequency of public access to the licensing process, the effectiveness and efficiency of the proposed changes, the additional burden that may be imposed on the regulator and the licensees, and the availability of all the necessary building blocks, in the CNSC's and licensees' organizations, that would permit such an approach.

It is expected that the Commission will deliberate the possible application of PSR in Canada in 2010, including potential implementation timelines. If the Commission Tribunal instructs staff to proceed with PSR implementation, it is anticipated that it will be introduced and implemented in Canada over a period of several years.

Recommendation R5 from IRRS Mission

*“CNSC should consider how to introduce effective arrangements for undertaking periodic safety reviews (PSRs) for these Class-1 facilities. Such PSRs should be proportionate and commensurate to the hazards to be controlled.”*

The CNSC will undertake an approach to introduce PSRs to Class I facilities (commensurate with the hazards posed by the respective facilities). The CNSC will build upon experience gained to date with refurbishment projects that have been performed, are underway, or are planning to be performed, related to the current fleet of NPPs using ISRs. ISRs are one-time applications of the IAEA PSR process, described in NS-G-2.10, to a refurbishment project. It is anticipated that full adoption of such a process in Canada would be introduced and implemented over a period of several years. Any decision on the use of PSRs will ultimately lie with the Commission Tribunal.

Suggestion S6 from IRRS Mission

*“Such PSRs should follow all of the elements set out in IAEA guides including the adoption of PSA (probabilistic safety analysis) for nuclear power plants (IAEA NS-G-2.10 or other appropriate safety guidance).”*

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If PSR is implemented, CNSC will prepare a comprehensive PSR implementation strategy, based on relevant IAEA guides. A PSR implementation project will build on:

- CNSC information and documentation and relevant IAEA documents, particularly the adoption of PSAs, as appropriate, as an important element of a PSR
- experience gained to date in the implementation of ISRs (see Article 14 (i) c) for completed re-start projects and on-going life extension projects
- international experience and lessons learned in the implementation of PSRs
- active engagement of international regulatory organizations, while preparing the comprehensive implementation strategy
- integrating inputs from the industry, both regularly and consistently
- results of the Licence Improvement Project

#### **14 (ii) Verification of Safety**

NPP licensees in Canada implement various programs to verify the safety of their facilities. These include testing (see subsection 14 (ii) a), aging management programs (see subsection 14 (ii) b), and maintenance of environmental qualification (see subsection 14 (ii) c).

##### **14 (ii) a Testing**

Operating licences for NPPs in Canada include general requirements for reliability of equipment, by citing CNSC document *Reliability Programs for Nuclear Power Plants* (S-98; see subsection 19 (iii) for more information). The operating licences also cite many references that include extensive requirements for testing safety-related components and systems. For example, requirements for testing special systems are described in

- CNSC document *Requirements for Containment Systems for CANDU Nuclear Power Plants* (R-7)
- CNSC document *Requirements for Shutdown Systems for CANDU Nuclear Power Plants* (R-8)
- CNSC document *Requirements for Emergency Core Cooling Systems for CANDU Nuclear Power Plants* (R-9)

The licensees execute periodic inspection programs for critical components and systems, as described in the next section. All NPP operating licences cite the requirements in CSA document *Periodic Inspection of CANDU NPP Components* (N285.4). Many of the other CSA standards mentioned in this report also contain specific testing requirements. The various testing requirements are addressed in the management systems, policies, and operational programs and procedures at the NPPs.

Thousands of safety-related tests are conducted annually at each NPP. These tests typically have a pass rate of the order of 99.9%. Testing to confirm the availability/functionality of safety and safety-related systems is also described in subsection 19 (iii).

#### **14 (ii) b Aging management**

All NPPs experience materials degradation issues. Structures, systems and components (SSC) 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 of SSCs occurring over time or with use.

Experience with several significant material degradation mechanisms during the life of currently operating nuclear power plants in Canada has led to the development, formalization and documentation for 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 systems, structures and components are maintained within the safe operating limits allowed by relevant codes and standards. The aging management programs are based on comprehensive methodologies that involve surveillance, the production and monitoring of system health reports, inspections by certified staff, and preventive maintenance. These plans are regularly reviewed and updated as required, to incorporate and allow for new information and findings. CNSC staff regularly reviews the results of activities covered by the aging management programs.

Feeders, fuel channels, and steam generators are inspected during outages, and restart is not allowed until the acceptability of the results is confirmed. Some of the aging management programs maintained by the licensees during the reporting period include the plans mentioned in the following paragraphs. A proposed CNSC regulatory framework document on aging management of NPPs is also described below.

#### Heat Transport System Materials Degradation Management Plan

This is an overview document summarizing the responsibilities, design requirements, operating experience, degradation mechanisms and acceptance standards for structures and components of the primary heat transport system (HTS). The document describes the strategy to manage HTS materials, and identifies specific component sub-programs and the key interfaces between various station programs and processes.

#### Feeder Pipe Management Plan

This program controls risks related to feeder aging and degradation mechanisms. It contains a review of contributing factors, and predicted degradation and failure rates, from which maintenance strategies are derived. Specific program inspection and corrective maintenance activities are described, including wall thickness inspections and programs to manage flow accelerated corrosion, preferential weld attack, fretting and cracking mechanisms and component replacement requirements.



### Fuel Channel Lifecycle Management and Inspection Plan

This plan reviews fuel channel degradation mechanisms with the potential to affect the life of fuel channels. The document also presents the strategies established to ensure the effects of component aging are monitored and managed effectively. It also discusses potential degradation mechanisms, such as dimensional changes due to service conditions (axial and diametral expansion, wall thinning and tube sag), deuterium uptake, fracture toughness changes due to service conditions and induced changes to material properties, pressure tube to calandria tube contact due to dimensional changes, and garter spring displacement and the potential for blister growth, as well as re-fuelling related service-induced damage to inside surfaces.

### Flow Accelerated Corrosion

This program identifies susceptible systems and monitors and manages degradation related to flow-accelerated corrosion in secondary side (non-nuclear) pipe-work systems. This program is based on the Electric Power Research Institute program CHECWORKS for assessment of predicted wear rates and remaining service life. A sub-program model is used for pipe-work that cannot be modeled using CHECWORKS, due to out-of-scope operating conditions or geometries (such as lines with entrained moisture, non-condensable gases and mitred fittings).

### Steam Generator Management Plan

This program controls risks related to steam generator aging and degradation mechanisms, and includes measures to detect, record, trend and mitigate these mechanisms. Program elements include tube wall inspections and inspections of other internal components, such as moisture separators, tie rods, feedwater boxes and nozzles, water chemistry management and primary and secondary side deposit management and removal (via water lancing, tube ID blasting, blow-down practices during operation, and occasional chemical cleaning).

### Containment

CNSC document *Requirements for Containment Systems for CANDU Nuclear Power Plants* (R-7) and CSA document *In-Service Examination and Testing Requirements for Concrete Containment Structures for CANDU Nuclear Power Plants* (N287.7) contain requirements for the design, construction, commissioning and in-service inspection of the concrete containment structures (CCSs). One of the licence conditions for NPP licensees is to develop and implement an in-service periodic inspection program for the CCSs. Licensees are required to perform periodic in-service inspection and testing of the CCSs at specified intervals, to ensure that their structural integrity and leak-tightness are maintained. The licensees submit the 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 document *Periodic Inspection of CANDU NPP Containment Components* (N285.5).

### Component Replacement

The Canadian nuclear industry has taken a number of initiatives to deal with the potential difficulties of securing replacement parts for aging NPPs. A joint procurement agreement allows

the industry to procure a number of replacement parts through the CANDU Owners Group (COG) for the mutual benefit of the industry, by creating enough demand for manufacturers to produce the required parts. The Canadian industry also has developed some capability to reverse-engineer and manufacture replacement parts that are no longer available. Canadian NPP licensees also have QA requirements embedded in their licences that require a review of the vendors' QA programs to ensure a quality product is delivered and is qualified to the proper level.

In addition to the above processes, the licensees and AECL have developed processes and procedures to allow replacing or substituting obsolete equipment components with components that have equivalent form, fit and function or are a nearly identical component replacement. The technical specification requires the replacement component to meet all of the design requirements and applicable codes and standards. This process was particularly useful during the environmental qualification projects described in the next section.

#### Proposed CNSC Regulatory Framework Document on Aging Management of NPPs

Many Canadian NPPs are approaching the end of their original intended operating lives, and some licensees are conducting refurbishment projects to extend their operation for up to 30 years. Extending the operating life depends, among other things, on the material condition of the plant, which is influenced significantly by how well aging has been controlled or managed. The CNSC is developing a document, *Aging Management of Nuclear Power Plants (RD-334)*, that will provide some of the regulatory requirements for aging management. The proposed requirements in RD-334 are consistent with the guidance in IAEA safety guide *Ageing Management for Nuclear Power Plant (NS-G-2.12)*.

RD-334 will emphasize the need for early and pro-active consideration of aging management for all stages of a plant's lifecycle: design, fabrication, construction, commissioning, operation, life extension, and decommissioning. As well, requirements are provided for establishment, implementation, and improvement of integrated aging management programs, through the application of a systematic and integrated approach, including organizational arrangements, data management, SSC selection, aging evaluation and condition assessment processes, documentation, and interfaces with other supporting program areas, including the review and improvement of the program.

It is foreseen that RD-334 will be referenced in the future in NPP operating licences, and will provide the basis for CNSC compliance activities related to aging management. In the meantime, the CNSC has advised licensees to follow IAEA safety guide NS-G-2.12.

#### **14 (ii) c Projects to update and maintain environmental qualification**

Challenge C-2 for Canada from the Fourth Review Meeting  
*“Reassure the environmental qualifications of safety and safety-related systems”*

Requirements for environmental qualification are specified in CSA document *Environmental Qualification of Equipment for CANDU Nuclear Power Plants (N290.13)*. This document is

being added to NPP operating licences as they are being renewed. By the end of the reporting period, most of the NPPs cited the required compliance with N290.13.

As described in the third Canadian report, all licensees began projects in the 1990s to provide re-assurance of the environmental qualification of safety and safety-related systems for all design basis accident conditions.

During the reporting period, the projects were superseded by ongoing programs to systematically sustain (and, if necessary, update) the environmental qualification of safety and safety-related systems. 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 emerging issues, to ensure that environmental qualification technical issues are managed in a timely way.

Particularly extensive environmental qualification activities were undertaken at Darlington to meet a regulatory commitment made in the previous reporting period. For example, various equipment upgrades related to environmental qualification were undertaken, such as those to improve the protection against steam during accident conditions. The completion of the remaining work is expected in the next reporting period, such that the requirements in CSA standard N290.13-05 will be met.

The CNSC continued to monitor the progress of these programs, in addition to ongoing inspections of these systems.

#### **14 (ii) d Independent external monitoring of safety performance**

##### World Association of Nuclear Operators (WANO) Reviews

All Canadian utilities are members of WANO. Each utility invites the WANO to perform peer reviews at the nuclear plants approximately every two years, to review performance, compare against international standards, and identify areas for improvement.

In a peer review, an NPP licensee invites a WANO team of about 20 people to spend two weeks at a plant, where they observe personnel performing their jobs, conduct interviews and review documentation. All areas are reviewed in accordance with specific WANO performance objectives and criteria.

WANO peer reviews in Canada during the reporting period included:

- Bruce B — September 2009
- Pickering A — June 2009
- Pickering B — July 2008
- Darlington — June 2007 and November 2009
- Gentilly-2 — February 2008
- Point Lepreau — October 2007

Planned WANO peer reviews in Canada during the next reporting period include:

- Bruce A — September 2010

- Pickering A — June 2011
- Pickering B — February 2011
- Darlington — 2012 (date to be confirmed)
- Gentilly-2 — March 2011 (tentative)
- Point Lepreau — Twelve months after the completion of the refurbishment

#### **14 (ii) e Verification of safety by CNSC staff**

The CNSC typically grants NPP operating licences for periods of five years (see subsection 7.2 (ii) d). However, safety analysis reports and safety system reliability studies are reviewed on a regular basis, typically at a frequency greater than that of operating licence renewal.

Licensees also submit, under S-99 (see subsection 7.2 (iii) b), reports of events to the CNSC, as well as quarterly and annual reports on matters such as operations, performance indicators, periodic inspections, status of pressure boundaries, radiation protection and reliability. The most safety-significant situations are pursued by special reviews or focused inspections, which are often followed up through specific action items for events at individual sites.

The licences issued by the CNSC specify requirements for the review and approval of changes to items in the licensing basis (defined in article 7.2 (ii) a), such as safety and safety-related SSCs, operating documentation and limits and other specified documentation. These conditions permit the CNSC to verify that proposed modifications to SSCs, operating procedures, or other limits, will not significantly erode the existing margin of safety for the plant that was agreed upon at the time of licensing.

Besides these specific types of assessments, the CNSC maintains permanent staff members at each NPP (as described in subsection 8.1 b) to monitor operations, verify safety, and conduct a wide range of inspections on a frequent basis.

The CNSC prepares an annual staff report on the safety performance of all Canadian NPPs. The *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants* integrates information gathered through CNSC staff verification activities of the NPPs and uses the rating system described in Appendix F to summarize the performance assessments of the safety areas and programs for each NPP. CNSC requirements and performance expectations in all safety areas were met or exceeded at all NPPs for all three years of the reporting period, with only a very small number of exceptions. Integrated plant ratings, which were generated for the NPPs for the first time in 2008, were either Fully Satisfactory or Satisfactory for all NPPs in both 2008 and 2009. Details on the CNSC rating system, and a summary table of the ratings during the reporting period, are provided in Appendix F. The ratings of specific safety areas are cited in this report under specific articles, where relevant.

## 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.

### 15 a General requirements and activities for radiation protection of workers and the public and protection of the environment

In Canada, high-level requirements related to controlling radiation exposure of nuclear energy workers and members of the public, as well as for protecting people and the environment by controlling the release of nuclear and hazardous substances, are found in the *General Nuclear Safety and Control Regulations*. Paragraph 12(1)(c) of the *General Nuclear Safety and Control Regulations* requires every licensee to take all reasonable precautions to protect the environment and the health and safety of persons. 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 12(1)(f) requires every licensee to take all reasonable precautions to control the release of nuclear substances or hazardous substances within the site of the licensed activity and into the environment, as a result of the licensed activity.

Section 4 of the *Radiation Protection Regulations* 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.

In addition, section 13 of the *Radiation Protection Regulations* requires that every licensee ensure that the following effective dose limits are not exceeded:

- 50 mSv in a year and 100 mSv over 5 years for a nuclear energy worker
- 4 mSv for a pregnant nuclear energy worker for the balance of pregnancy
- 1 mSv per year for a person who is not a nuclear energy worker (public)

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 Paragraph 6(1) of the *Radiation Protection Regulations* 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 is reached, the licensee must report to the CNSC, conduct an investigation to establish the cause for reaching the action level, and identify and take action to restore the effectiveness of the radiation protection program. NPP operating licences cite the CNSC document *Reporting Requirements for Operating Nuclear Power Plants (S-99)*, which requires licensees to file a report to the CNSC within 45 days of being aware that an action level has been reached. These reports must describe the results of the investigation, identify the actions taken to restore the

effectiveness of the radiation protection program, and identify any missing information and further describe how and when the information will be provided to the CNSC.

Additional information on the *Radiation Protection Regulations*, dosimetry requirements, and guidance related to ALARA and setting action levels is provided in Annex 15 a.

The CNSC regulatory policy *Protection of the Environment* (P-223) describes the principles and factors that guide the CNSC in regulating 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 in a manner consistent with Canadian environmental policies, acts and regulations, and with Canada's international obligations. P-223 states that licensees should prevent unreasonable risk by applying the ALARA principle to all releases to the environment.

The CNSC document *Environmental Protection, Policies, Programs and Procedures at Class I Nuclear Facilities and Uranium Mills and Mines* (S-296) was issued during the previous reporting period. It stipulates an integrated set of documented activities (an environmental management system) as the means to adequately provide for the protection of the environment at Class I nuclear facilities and uranium mines and mills. By the end of the reporting period, S-296 was incorporated into the operating licences for Bruce A and B. CNSC plans to continue incorporating it in the other operating licences, during the next reporting period.

To fulfill the relevant requirements for radiation and environmental protection, Canadian NPP licensees establish, maintain and document programs to effectively manage and control radiological risk to workers, the public and the environment from nuclear operations. These programs have the following objectives:

- to maintain a low level of public risk compared to other normal public risks that arise from industrial activity
- to subject workers only to radiological risks that are low, understood, and voluntarily accepted

More specifically, to achieve the ALARA principle, the licensees implementation programs for:

- management control over work practices
- personnel qualification and training
- control of occupational and public exposure to radiation
- planning for unusual situations

A specific example of measures taken by an NPP licensee to protect the environment (reduction of fish impingement and entrainment) is provided in Annex 17 (iii) a.

To verify compliance with licence conditions and CNSC regulations, CNSC staff reviews documentation and operational reports submitted by licensees, and evaluates the implementation of licensees' radiation protection and environmental protection programs through desktop reviews and onsite inspections.

CNSC staff also:

- monitors and evaluates the radiological and environmental impacts of licensed activities
- reviews documentation and applications submitted by licensees
- conducts onsite evaluations of dosimetry service applicants

For events (reported through S-99) related to potential and actual exposure to radiation and hazardous substances, CNSC staff reviews the reporting and analysis processes of licensees, to verify their compliance with regulatory requirements and effectiveness in correcting weaknesses. CNSC staff also investigates significant events.

## **15 b Radiation protection for workers and application of the ALARA principle**

### Strategies to Minimize Doses to Workers

To minimize doses to workers, licensees implement comprehensive ALARA strategies. The following text presents examples of three particular licensee strategies to minimize the dose to workers: radiological exposure permits, airborne tritium reduction, and source term reduction.

Radiological exposure permits set out job dose limits for all planned and emergent radiological work. Job dose limits are determined using operating experience, work planning checklists, and walkdowns to identify exposure hazards. The NPPs' ALARA sections assess job dose limits for adherence to ALARA principles before preparing and approving the radiological exposure permit. Radiation protection issues are discussed before performing the work, and are addressed in pre-job briefings.

Radiological exposure permits help to control doses by allowing them to be tracked by job, which helps to present radiation protection-related challenges during pre-job briefings. This reduces the probability of unplanned exposures that exceed the internal investigation level, and facilitates post-work ALARA reviews of high-hazard or high-dose jobs.

Several initiatives have been undertaken to reduce doses from tritium, including more frequent replacement of desiccant in dryer units and improvement of the material condition of dryer systems. Some licensees have also placed dehumidifiers on the air inlets of reactor buildings, installed alarming area tritium monitors, de-tritiated their heavy water inventory, and emphasized training on the potential hazards of tritium. The majority of doses due to airborne tritium arise from the heat transport system, due to its higher temperature and pressure relative to those of the moderator system. To further limit tritium exposure, some licensees are also reinforcing the need to plug plastic suits at every opportunity to refill them with fresh air (thereby limiting unplugged periods to 60 seconds).

Wherever consistent with the principle of ALARA, hot spots, which can increase radiation fields and contribute to radiation doses, are identified and removed. In addition to the removal of existing hot spots, licensees are working to reduce the recurrence of hot spots through initiatives that involve reduction of the filter pore size, or increase in the flow rate in the heat transport purification system.

Each year, licensees establish aggressive radiation dose targets, which are essentially constraints as recommended in the IAEA Safety Guide *Radiation Protection and Radioactive Waste Management in the Operation of Nuclear Power Plants* (NS-G-2.7). These targets are based on planned activities and outages for the year; therefore, both targets and doses vary annually.

#### Doses and CNSC Assessment of Radiation Protection Programs for Workers

Doses to plant personnel were below regulatory limits during the reporting period (see Annex 15 b for doses to personnel 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

In 2009, there was a significant event at Bruce Unit 1, involving elevated levels of airborne alpha contamination during refurbishment work and potential exposures of a large number of workers. CNSC concluded that Bruce Power took appropriate action to contain the contamination and protect the health and safety of workers. It was also determined that there was no risk to the public or the environment as a result of this event. See Appendix D for details.

The performance of the CNSC Radiation Protection safety area is assessed annually for all licensees in the *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants*. The Radiation Protection safety area covers aspects of radiation protection for workers, but radiation protection for the public is covered by a separate safety area (Environmental Protection, described below). During the reporting period, all licensees had satisfactory performance under the Radiation Protection safety area. See Appendix F for a full definition of this safety area (Table F.1), and a table of the performance ratings of the licensees during the reporting period (Table F.2).

### **15 c Environmental protection and radiological surveillance**

#### Programs to Control and Monitor Radioactive Releases

Radioactive material released into the environment through gaseous and liquid effluents from NPPs can result in radiation doses to members of the public through direct irradiation. The doses received by members of 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 effluent limits are derived from the public dose limit of 1 mSv, and are called derived release limits (DRL). A DRL is an effluent release limit for a particular route of release from a particular station. If the station exceeds its DRL, members of the public with the greatest exposure may exceed the public dose limit.

The calculation of DRLs is based on the methodology in CSA document *Guidelines for Calculating Derived Release Limits for Radioactive Material* (CSA N288.1), and 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, critical group characteristics, site specific data etc.) Calculation of DRLs can vary from simple to very



complex. As a result, DRLs should be reviewed and, if necessary, updated approximately every five years. During the reporting period, DRLs were revised for Bruce A and B and Pickering A and B according to the revised methodology of CSA N288.1-2008. Point Lepreau and Gentilly-2 are currently revising their DRLs.

Licensees set action levels well below the DRLs. These targets are based on the ALARA principle and are unique to each facility, depending on the individual factors. An action level, if exceeded, provides a warning of a possible loss of control in the control systems, and allows for prompt corrective action. This enables licensees to keep liquid and gaseous effluent releases well below their respective DRLs.

Canadian NPPs have established programs to control and monitor the effect of operations on human health and the environment. 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 and liquid effluents from Canadian NPPs from 2006 to 2009 are tabulated in Annex 15 c. During the reporting period, the majority of releases from all NPPs were kept at less than 1% of the DRLs. From 2006 to 2009, there were no reported cases of environmental action levels being exceeded.

In addition to tracking radiological emissions from the NPP, licensees have instituted radiological environmental monitoring programs, to monitor radioactivity near the facilities in the air and in substances that people eat, drink and come in contact with. These environmental monitoring programs have the following four objectives:

- to confirm that emissions of radioactive materials are within the DRL for specific nuclides or nuclide groups
- to verify that the assumptions made in deriving DRLs remain valid
- to permit an independent estimate to be made of doses to critical members of the public resulting from emissions
- to provide data to aid in the development and evaluation of models that adequately describe the movement of radionuclides through the environment

The Canadian Radioactivity Monitoring Network, established by Health Canada, offers Canadians more accurate health assessments based on existing levels of radioactivity near NPPs, as well as radioactivity that may result from a nuclear accident. The program consists of monitoring ambient gamma radiation at 34 sites, radioactive aerosols at 26 sites, and atmospheric tritium at 15 sites. These tests are augmented in a few locations with drinking water and milk sampling. The Ontario Ministry of Labour's Radiation Protection Service also monitors environmental radiation within the province of Ontario. See the first and second Canadian reports for more details on these monitoring programs.

#### Release of Hazardous Substances

In addition to regulating the control of radioactive effluent releases, the CNSC also requires licensees to control and monitor their releases of hazardous substances. The licensees monitor

the releases of hazardous substances in compliance with the various applicable local, provincial and federal regulations, and in accordance with CNSC regulations, policies and guides.

#### CNSC Assessment of Environmental Protection Programs

The performance of the CNSC Environmental Protection safety area is assessed annually for all licensees in the *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants*.. The Environmental Protection safety area covers radiological exposure of the public, as well as exposure of the environment to radioactive and hazardous substances. During the reporting period, all licensees demonstrated satisfactory performance under this safety area (with a single exception in 2008). See Appendix F for a full definition of this safety area (Table F.1), and the performance ratings of the licensees during the reporting period (Table F.2).

## **Article 16 – Emergency Preparedness**

1. Each Contracting Party shall take the appropriate steps to ensure that there are 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 Responsibilities of the licensees, regulatory body and other authorities**

Nuclear emergency preparedness and response in Canada is a multi-jurisdictional responsibility, shared by the federal, provincial and municipal governments, as well as licensees. Nuclear emergency planning includes plans for both onsite and offsite emergencies.

Onsite nuclear emergencies are those that occur within the physical boundaries of a Canadian NPP, and for which licensees are responsible. Offsite nuclear emergencies are those emergencies having an effect outside the boundaries of a Canadian NPP, and for which provinces have the primary responsibility. The provinces also designate municipalities within their jurisdictions to plan for offsite nuclear emergencies.

The provincial governments are responsible for the following activities:

- overseeing the general health, safety and welfare of the inhabitants of their respective provinces and the protection of the environment
- enacting legislation to fulfill the province's lead responsibility for public safety
- preparing emergency plans and procedures and providing direction to municipalities so designated
- assuming lead responsibility for the arrangements necessary to respond to the offsite effects of a nuclear emergency
- coordinating support from the NPP and the Government of Canada during preparedness activities and during response

The Government of Canada coordinates federal actions in support of the provinces during a nuclear emergency. Potentially, this collective responsibility encompasses a wide range of

contingency and response measures to prevent, correct, or eliminate accidents, spills, abnormal situations and emergencies.

The Government of Canada has procedures to respond to emergencies with international or inter-provincial implications and is responsible for the following activities:

- liaison with the international community
- liaison with diplomatic missions in Canada
- assisting Canadians abroad
- coordinating the national response to a nuclear emergency occurring in a foreign country

A federal department, Public Safety Canada, integrates into a single portfolio the core activities that secure the safety of Canadians in emergencies, including nuclear emergencies. NPPs and nuclear technologies have been identified as “critical infrastructure”, which includes those physical and information technology facilities, networks and assets which, if disrupted or destroyed, would have a serious impact on the health, safety, security or economic well-being of Canadians.

### **16.1 b Onsite emergency plans**

Onsite nuclear emergency plans are required by a licence condition for operating NPPs. 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. Specifically, the application must describe the proposed measures to address the following situations:

- 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

After the plans have been reviewed and accepted by the CNSC, they become binding upon the licensee, as a condition in the operating licence. Descriptions of the onsite emergency plans for each NPP are provided in Annex 16.1 b.

Licensees develop formal emergency preparedness programs, to ensure they are capable of executing their plan. Emergency preparedness programs are updated and fine-tuned over the life of the facility as new requirements are identified, or to address changing conditions or identified deficiencies. Notwithstanding the fact that the programs have matured and are well-maintained, the CNSC staff has observed that NPP operators in Canada proactively seek ways to continuously improve their emergency preparedness programs.

The performance of the CNSC Emergency Preparedness safety area is assessed annually for all licensees in the *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants*. During the reporting period, all licensees had either satisfactory or fully satisfactory performance

in this safety area. See Appendix F for a full definition of this safety area (Table F.1) and the performance ratings of the licensees during the reporting period (Table F.2).

### **16.1 c Offsite (provincial and territorial) emergency plans**

The Canadian provinces and territories, in cooperation with local jurisdictions, have established plans to deal with any significant offsite nuclear impacts. Typically, their administrative structure includes an emergency measures organization, or equivalent, to cope with a wide range of potential or actual emergencies in accordance with defined plans and procedures.

The provincial and territorial emergency preparedness plans provide for coordination with other relevant jurisdictions and organizations. They anticipate the involvement and support of the Government of Canada at the national level, the involvement and support of governments at the local level, and extensive participation by departments and agents of all levels of government. More details on this coordination are provided in subsection 16.1 d.

Typically, the provincial plans provide for urgent protective actions if required and include the following measures:

- limiting access to the affected zone
- providing temporary shelter to the affected population
- blocking thyroid uptake of radiation
- evacuating areas near the NPP

The plans also recognize that ingestion control measures (e.g., effecting a quarantine of farm animals, banning the sale of affected food, or restricting the use of affected drinking water) for a larger area could be necessary.

The offsite nuclear emergency plans of the provinces that host NPPs are described in Annex 16.1 c.

### **16.1 d Federal emergency plans**

#### Federal Nuclear Emergency Plan

To the extent possible, the Government of Canada's emergency planning, preparedness and response are based on an "all-hazards" approach. Because of the inherent technical nature and complexity of a nuclear emergency, hazard-specific planning, preparedness and response arrangements are required. These special arrangements, which are one component of the larger federal emergency preparedness framework, constitute the Federal Nuclear Emergency Plan (FNEP). This plan describes the Government of Canada's preparedness and response to a nuclear emergency. Health Canada is the lead federal department for the FNEP.

The FNEP is intended to complement the relevant nuclear emergency plans of other jurisdictions inside and outside Canada. It describes the measures the Government of Canada will follow to manage and coordinate federal response activities to nuclear emergencies that could affect Canada. The FNEP is activated if federal support to a Canadian province or territory is required, as a consequence of any domestic, trans-boundary (e.g., Canada and the United States) or international incident.

Under the common administrative framework of the plan, the development and implementation of emergency preparedness and response plans to offsite nuclear emergencies is primarily a provincial responsibility. However, there are direct inputs from the local government, the licensee, and federal departments and agencies. This allows the various jurisdictions and organizations that have responsibilities for aspects of nuclear emergency preparedness to discharge their responsibilities in a cooperative, complementary and coordinated manner.

There are 19 federal departments/agencies involved in the FNEP. In keeping with the FNEP, federal policies and Canadian legislation, these participants are also responsible for independently developing, maintaining and implementing their own nuclear emergency response plans. The CNSC has clearly defined roles within the context of the FNEP. For instance, it is a core member of each of the FNEP's three organizational groups (coordination/operations, technical advisory and public affairs), and participates in emergency planning activities with other FNEP core agencies.

Annex 16.1 d describes the provisions of the FNEP.

#### Emergency Plans of Federal Departments and Agencies

The CNSC has its own nuclear emergency response plan. A general description of the CNSC's role in emergency preparedness is provided in Annex 16.1 d. The CNSC also has a well developed and mature nuclear emergency management program, based on CNSC regulatory policy *Nuclear Emergency Management* (P-325) and its emergency response plan.

Other federal departments and agencies also develop their own nuclear emergency response plans. For example, Transport Canada administers the *Canadian Transportation of Dangerous Goods Regulations* and operates the Canadian Transport Emergency Centre, to ensure that hazardous substances are transported safely, and to help emergency response personnel handle related emergencies, including those involving nuclear substances. The CNSC and Transport Canada cooperate in emergencies and incidents involving nuclear substances in accordance with the FNEP, relevant federal legislation, and formal administrative arrangements.

#### **16.1 e Exercises and drills**

Emergency drills are designed to provide a training opportunity to enhance the ability of involved parties to respond to emergency situations and protect public health and safety during an event at an NPP or other licensed nuclear facility. Emergency exercises serve to test the sharing of information and to ensure all response efforts are coordinated and communicated effectively.

CNSC staff evaluates the full-scale emergency exercises at the NPPs, to ensure that licensees are effectively managing and implementing their emergency response. During the reporting period, six such exercises were evaluated.

In some cases, the municipalities, the province and the CNSC will also participate in the exercise to a certain degree. The CNSC participates in emergency exercises with NPP licensees, to ensure communication lines are in place and in a state of readiness. Other federal departments may

participate in provincial nuclear emergency exercises focused on emergencies originating at NPPs, in order to evaluate the transfer of information and deployment of federal resources.

In October 2007, the CNSC participated in the TOPOFF-4 exercise, which was led by the U.S. Congress and simulated terrorist events that took place in the U.S.A. and Guam. This event had potential impacts for the safety and security of the general public living in Canada and the environment.

During the summer of 2008, the CNSC participated in the ConvEx-3 exercise, which was simulated at the Laguna Verde NPP in the Mexican state of Veracruz, off the Gulf of Mexico. The CNSC sent representation to Health Canada to partake in the various discussions involving the technical advisory group, the coordination and operations group and the public affairs group.

During the reporting period, the CNSC was also involved in various national exercises including an in-house exercise to better prepare for the safety and security of the Vancouver 2010 Olympic Winter Games. The aim of these exercises was to practice and evaluate some of the arrangements in place to respond to a nuclear or radiological emergency in Vancouver and surrounding area. The Winter Games, which took place in mid-February, 2010, were successful, and no significant radiological or nuclear problems were reported.

#### **16.1 f Emergency preparedness expectations for new-build**

The CNSC is establishing requirements and expectations for emergency preparedness for new-build projects. The CNSC document *Site Evaluation for New Nuclear Power Plants (RD-346)* specifies that the following issues related to population and emergency planning must be considered when evaluating a proposed site against safety goals:

- population density and distribution within the protective zone, with particular focus on existing and projected population densities and distributions in the region including resident populations and transient populations (updated over the lifetime of the NPP)
- present and future use of land and resources
- physical site characteristics that could impede the development and implementation of emergency plans
- populations in the vicinity of the NPP that are difficult to evacuate or shelter (for example, schools, prisons, hospitals)
- ability to maintain population and land-use activities in the protective zone at levels that will not impede implementation of the emergency plans

The protective zone is defined as the area beyond the exclusion zone that needs to be considered with respect to implementing emergency measures. 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, and is expected to demonstrate consideration of effective dose under normal operation and accident conditions, the design basis threat and emergency preparedness.

Prior to construction, the proponent is expected to 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 not be compromised during the entire lifecycle of the proposed site. For example, if a hospital expansion is anticipated as part of a long-term emergency plan, then discussions between the proponent and the municipality should begin at the site evaluation stage, so that appropriate agreements are in place prior to construction.

As mentioned in subsection 7.2 (ii) a, the CNSC is preparing a licence application guide related to application for a licence to construct that will elaborate on these expectations. These expectations will also be conveyed, at a high level, to potential applicants in a licence application guide for a licence to prepare site, in order to confirm the applicant has a forward-looking emergency preparedness program in place, as a part of the overall site characterization program.

The CNSC extends these considerations of emergency preparedness into the requirements for the licence to construct and the licence to operate. The CNSC document *Design of New Nuclear Power Plants* (RD-337) states additional, specific criteria related to emergency preparedness to be considered at the design and construction stage:

- The containment design allows sufficient time for the implementation of offsite emergency procedures.
- 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 plant accident management and emergency procedures.

## **16.2 Information to the Public and Neighbouring States**

### **16.2 a Measures for informing the public during a national nuclear emergency**

Typically, the offsite nuclear emergency plans of the provinces, along with the affected municipalities and the NPP licensees, coordinate and provide to the public, urgent protective actions, if required.

During the reporting period, the public alerting system for NPPs in Ontario was expanded from the contiguous zone (3 km) to the primary zone (10 km). This public alerting system, coupled with the instructional messages broadcast over the radio and the television, will ensure that the population within the primary zone is notified appropriately and in a timely manner.

The FNEP describes overall coordination in the event of a national nuclear emergency in Canada. Information is to be provided at the national level to members of the media and the public through a central point of contact: the Public Affairs Group. The Public Affairs Group serves as the federal coordination point for the collection, generation and distribution to the public and the news media of information concerning the emergency.

The Public Affairs Group is made up of representatives of organizations that have defined responsibilities within the structure of the FNEP, along with other organizations and governments involved in a specific nuclear emergency.



**16.2 b International arrangements, including those with neighbouring countries**

Canada participates in the IAEA International Nuclear Event Scale (INES) reporting system. In addition, Canada is a signatory of the following three international emergency response agreements:

*Canada-U.S. Joint Radiological Emergency Response Plan (1996)*

This joint plan focuses on emergency response measures of a radiological nature, rather than generic civil emergency measures. It is the basis for cooperative measures to deal with peacetime radiological events involving Canada, the United States, or both countries. Cooperative measures contained in the FNEP are consistent with the joint plan.

*Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (1986)*

Developed under the auspices of the IAEA, the purpose of the agreement is to provide for cooperation between signatories, to facilitate prompt assistance in the event of a nuclear accident or radiological emergency to minimize its consequences and to protect life, property, and the environment, from the effects of radioactive releases. The agreement sets out how assistance is requested, provided, directed, controlled, and terminated. This Convention has yet to be ratified, pending a review of domestic implementing legislation.

*Convention on Early Notification of a Nuclear Accident (1987)*

Also developed under the auspices of the IAEA, this Convention defines when and how the IAEA should be notified of an event with potential trans-boundary consequences, and when and how the IAEA would notify the signatories of an international event which could have an impact in their respective countries.

**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.

The framework and process for issuing a licence to prepare site for an NPP are described in subsection 7.2 (ii), with details in subsection 7.2 (ii) b..

‘Siting’ in Canada is composed of site evaluation and site selection. As mentioned in subsection 7.2 (ii) b, the selection of a site is itself not a regulated activity. However, the resultant site selection case is assessed as part of the application for a licence to prepare a site. As outlined in the CNSC document *Site Evaluation for New Nuclear Power Plants (RD-346)*, prior to the triggering of the environmental assessment (EA) and licensing processes, the proponent 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 site, which will be reviewed by the CNSC and other applicable federal authorities.

### Level of NPP Design Information Expected to Demonstrate Site Suitability

The EA process and the consideration of an application for a licence to prepare a site for a new NPP in Canada do not require a proponent to select a specific design. However, the CNSC does not accept a ‘black box’ approach to siting. CNSC balances the level of design information required with the extent of safety assurance desired for any designs being contemplated for the proposed site. The depth of plant design information contributes significantly to the credibility of the applicant’s case for both the EA and application for a licence to prepare site.

The decisions made by a Joint Review Panel and the Commission Tribunal on an EA under the *Canadian Environmental Assessment Act* and an application for a licence to prepare site under the NSCA for a new NPP may be made with high-level facility design information from a range of reactor designs, without specifying the technology to be constructed. The design information provided by the proponent must be credible and sufficient to adequately bound the evaluations of

environmental impacts and site suitability from a range of reactor designs that might later be deployed at the site, and be the subject of an application for a licence to construct.

The bounding design parameters would have to contain sufficient information to describe the plant-site interface and take into consideration the characteristics of the proposed site.

The underpinning of the bounding approach is that the environmental impacts of the reactor design eventually selected for construction should be less than the bounding impacts assessed in the EIS. Similarly, if the site is deemed suitable to host nuclear units using bounding parameters, then the site should also be suitable for any reactor design that falls within the approved bounding envelope.

The design that is eventually selected for construction would have to fit within the bounding envelope in the approved EA. This evaluation would be performed once a reactor technology is selected, and will be required to be demonstrated as part of an application for a licence to construct.

CNSC will accept high-level information in support of the site selection case, with the understanding that there will be an increased level of regulatory scrutiny during the construction and operation licensing processes, to validate the claims made. At the licence to construct application phase, the applicant will be expected to submit detailed design information that will 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 is:

- a technical outline of the facility layout
- qualitative descriptions of all major systems, structures and components (SSCs) that could significantly influence the course or consequences of principal types of accidents and malfunctions
- qualitative descriptions 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 (natural and human-induced), design basis accidents and beyond design basis accidents (severe accidents)

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  $10^{-6}$ , but sufficiently close to this frequency, the rationale for not including them from further analysis should be provided.

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 a trigger for a temporary 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 site would be limited to site preparation activities that are independent of any specific reactor technology (e.g., clearing and grading the site, building site support infrastructure such as roads, site power, water and sewer services, but not including excavation for the purposes of establishing the facility footprint).

Regardless of the approach used by a proponent to apply facility design information to its site selection case, a fundamental expectation of the CNSC is that the applicant will demonstrate a ‘smart buyer’ philosophy. This means that it will be expected to demonstrate a clear understanding of the technologies it is proposing to use and the bases from which the site selection case is developed.

#### Site Evaluation Criteria - General

The information provided in an application for a licence to prepare site is assessed against the criteria described in CNSC document *Site Evaluation for New Nuclear Power Plants* (RD-346). RD-346 articulates CNSC 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 f) and evaluation of risks to individuals, the surrounding population and the environment

RD-346 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.

Additional details related to site evaluation criteria are provided under subsections 17 (i) and 17 (ii) below.

#### Site Evaluation During the Review Period

During the reporting period, Bruce Power and OPG submitted applications for licences to prepare a site. Initial steps toward conducting the necessary environmental assessment and reviewing the application were taken. Although Bruce Power subsequently withdrew its applications, OPG proceeded, as described in subsection D.3 of Chapter I.

For the purposes of the necessary EA related to the OPG application, a Joint Review Panel of three persons was appointed by the federal minister of the Environment and the governor in council, in consultation with the president of the CNSC. In addition to the Joint Review Panel chair, who is a member of the Commission Tribunal, the remaining panel members were also appointed as temporary members of the Commission Tribunal, for the purposes of issuing the licence to prepare site upon the successful completion of the EA.

In September 2009, OPG submitted their EIS submissions in support of the EA and remaining licensing submissions in support of the licence to prepare site, and this initiated a six-month public comment period led by the Joint Review Panel. This includes the CNSC review period, during which time CNSC staff will review the EIS and licensing submissions against the review criteria to determine whether:

- the applicant is qualified to carry on the activity authorized by the licence
- the proposed site is suitable for future development, and the activities encompassed by the licence to prepare site will not pose, for the entire lifecycle of the proposed facility, an unreasonable risk to health, safety, security and the environment for the site and its surrounding region.

### **17 (i) Evaluation of Site-Related Factors**

The CNSC licence application guide for a licence to prepare site, currently being drafted, will elaborate upon the criteria for evaluating the effect of the site on the safety of the NPP (see subsection 7.2 (ii) a for details).

The site selection case should address the site impact on the safety of the NPP. This includes the susceptibility to flooding (storm surge, dam burst etc.), hurricanes, tornados, ice storms or other severe weather, and earthquakes. RD-346 requires the applicant to consider climate change when evaluating the potential impact of these phenomena. This category also includes the proximity of the site to one or more of the following examples:

- 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)
- neighbouring propane storage facilities or refineries (possibility of industrial accidents)
- military test ranges (possibility of stray missiles)

The above concerns are further impacted 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 each licence under the NSCA (and the EIS), the results of which are integrated into the safety case (discussed further under subsections 17 (ii) and (iii)). Submissions to the licensing (and EA) processes 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**

The CNSC licence application guide for a licence to prepare site, currently being drafted, will elaborate upon the criteria for evaluating the impact of the NPP on the surrounding population and the environment (see subsection 7.2 (ii) a for details).

Prior to the CNSC issuing a site preparation licence, a positive decision regarding an EA is required. The EA process evaluates the effects of the construction and operation of a proposed NPP on the environment. The CNSC separately evaluates the licence applicant's proposed measures to protect individuals, society, and the environment using criteria for the applicant's proposed programs for radiation protection (which includes dose control) and environmental protection (which includes control of releases of hazardous substances).

The performance of the CNSC Environmental Protection safety area is also assessed annually for all currently operating NPPs in the *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants*. The Environmental Protection safety area covers programs that protect the public and environment from releases of radioactive and hazardous substances. During the reporting period, all the licensees had satisfactory environmental protection performance, with one exception: Pickering was rated Below Expectations in 2008. Issues related to the impact of the NPP on the local fish population at Pickering were being adequately addressed by OPG by the end of the reporting period — some of the measures taken are described in the example in Annex 17 (iii) a. See Appendix F for a full definition of the CNSC safety areas (Table F.1) and the performance ratings of the licensees during the reporting period (Table F.2).

**17 (ii) a Environmental assessment**

The EA process under the *Canadian Environmental Assessment Act* (CEA Act) is described in Annex 17 (ii) a.

The scope of the EA under CEA Act must include the following factors:

- the environmental effects of the project, including the environmental effects of malfunctions or accidents that may occur in connection with the project, and any cumulative environmental effects that are likely to result from the project in combination with other projects or activities that have been, or will be, carried out
- the significance of the effects identified above
- comments from the public
- measures that are technically and economically feasible and that would mitigate any significant adverse environmental effects of the project

Depending on the circumstances, under the CEA Act, the CNSC may also require consideration of these elements:

- the purpose of the project
- the need for the project
- alternatives to the project
- alternative means of carrying out the project that are technically and economically feasible, and the environmental effects of any such alternative means
- traditional and local knowledge, where relevant

- the need for, and requirements of, a follow-up program in respect of the project
- the capacity of renewable resources that are likely to be significantly affected by the project to meet the needs of the present and those of the future

Opportunities for public, Aboriginal and other stakeholder input are provided during the EA process. These may include a variety of proposed activities such as Web site postings, open houses, workshops, written communications and hearings.

#### **17 (ii) b Criteria for evaluating the safety impact of the NPP on the surrounding environment and population**

The impact on the environment is evaluated by examining the effects on parameters such as water supply, air quality, wildlife, lakes and rivers. Such evaluation criteria are identified in the EA guidelines, and assessed by the applicant in the EIS that is produced to satisfy relevant provincial and federal laws (see Annex 17 (ii) a).

The safety impact on the population examines the population dose from postulated design basis 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 number, nature (subdivision, rural, industrial, school, hospital etc.), and distribution of population around the facility. The applicant addresses these criteria in the safety analysis report, which calculates the population doses and verifies that the NPP design meets its safety targets.

#### **17 (ii) c New-build outreach**

Outreach to stakeholders and the local populace of the potential site is an important activity related to understanding the impact of a proposed NPP on the population and the environment, to explain that impact and how it is evaluated.

During the reporting period, significant outreach was conducted by both Bruce Power and OPG regarding their new-build projects, which are briefly described in subsection D.3 of Chapter I. Detailed descriptions of the outreach activities, which included Aboriginal consultation, are provided in Annex 17 (ii) c.

The CNSC also conducted significant outreach during the reporting period, to familiarize stakeholders in new-build applications, and to explain the CNSC's mandate and the regulatory process. For example, CNSC staff travelled to Alberta to engage the Aboriginal community and to explain to stakeholders and local residents the EA process and the public's role in it, aspects of nuclear safety, and the licensing process for new-build. A general description of CNSC outreach is provided in subsection 8.2 b.

**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 subsections 17 (i) and 17 (ii) is periodically verified. Possible changes to the site demographics, or significant changes to the understanding of local environment, include the following:

- discovery of new fault lines affecting seismicity at the site
- changes to man-made neighbouring facilities, such as a newly constructed oil refinery, rail corridor, airport flight path, or chemical plant
- climate change

Such changes must be examined through activities including regular reviews of emergency response measures, security measures, and the safety analysis report (see subsection 14 (i) a). The safety analysis report contains sections with the following information:

- demographics
- weather experience
- seismicity
- neighbouring facilities
- air and rail transport corridor activity

According to the NPP operating licence condition that cites CNSC document *Reporting Requirements for Operating Nuclear Power Plants (S-99)*, each of the current NPP licensees is required to submit an annual report to the CNSC, detailing the results of environmental radiological monitoring programs, together with an interpretation of the results and estimates of radiation doses to the public resulting from NPP operations. The results from these monitoring programs are used to ensure the public legal limit in Canada for effective dose from the operation of NPPs is not exceeded.

Probabilistic safety assessments (PSA) for Canadian NPPs are performed according to the requirements in CNSC document *Probabilistic Safety Assessment for Nuclear Power Plants (S-294)*. S-294 requires Level 2 PSAs to address external events (any event that proceeds from the environment, which includes, but is not limited to, earthquakes, floods, and hurricanes). PSAs are described in more detail in subsection 14 (i) b. In turn, PSAs are used to identify postulated initiating events for deterministic analysis.

Specific examples of measures undertaken by the NPP licensees to re-evaluate and address, as necessary, site-related factors, are provided in Annex 17 (iii) a.

**17 (iii) b Results of environmental assessments for life extension projects**

Applying the EA process to refurbishment and life extension projects help ensure the continued operational safety of NPPs. The following briefly describes the status and results of EAs for life extension projects (refer to subsection D.2 of Chapter I and subsection 14 (ii) for other information on these projects).

Screening-level EAs have been completed for refurbishment and life extension projects (or elements thereof) for several NPPs (Bruce B in June 2005, Bruce A in May 2006, Gentilly-2 in December 2006, and Pickering B in January 2009). In all cases, the CNSC, as the responsible authority, determined that the project was not likely to cause significant adverse effects on the environment, taking into account identified mitigation measures.

**17 (iv) Consultation with Other Contracting Parties Likely to be Affected by the Installation**

Canadian legislation and process — and, in particular, the CEA Act and its regulations, and the federal EA and review process — do not obligate proponents of domestic NPPs that could affect the United States of America, to consult with United States jurisdictions or the American public regarding the proposed siting of the NPP. However, potentially significant effects from such proposals would be considered to their full geographic extent, regardless of political boundaries or borders. Representatives or individuals from other jurisdictions also have the opportunity to participate in the CNSC's licensing process, as interveners.

In addition, the Government of Canada and the Government of the United States of America, in cooperation with state and provincial governments, are obligated to establish programs to abate, control and prevent pollution from industrial sources. These programs include measures to control the discharges of radioactive materials into the Great Lakes system, by virtue of the Great Lakes Water Quality Agreement.

The CNSC and the Nuclear Regulatory Commission of the United States of America have a long practice of cooperation and consultation since the 1950s. In 1996, they entered into a bilateral administrative arrangement for cooperation and exchange of information on nuclear regulatory matters. This commitment includes, to the extent permitted under laws and policies, the exchange of certain technical information that “relates to the regulation of the health, safety, security, safeguards, waste management and environmental protection aspects of the siting, construction, commissioning, operation and decommissioning of any designated nuclear facility” in Canada and the United States of America.

## **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. The first and second Canadian reports contain extensive information on the evolution of the design and construction of CANDU-type NPPs.

During the reporting period, the CNSC considered applications for licences to site an NPP, but did not receive any applications for a licence to construct. The status of licence applications related to new build in Canada is discussed in subsection D.3 of Chapter I. The general framework and process for issuing a licence to construct a Class IA nuclear facility (of which an NPP is an example) are described in subsection 7.2 (ii).

In preparation for new-build licence applications, the CNSC is updating its design requirements for NPPs, participating in the Multinational Design Evaluation Program (MDEP), conducting pre-project vendor design reviews, and participating in the development of the Nuclear Code of Conduct for NPP vendor countries. These activities are described in the following subsections. In addition, the general provisions for applying new design requirements to the currently operating NPPs in Canada are also described in this introduction to Article 18. Specific design requirements and provisions related to defence in depth, proven technologies, and reliable, stable, and easily manageable operation are described in subsections 18 (i), 18 (ii), and 18 (iii), respectively, for both new build and the currently operating NPPs.

In preparation for licence applications related to new-build, CNSC is also developing staff review procedures to coordinate its review of submissions of applications for a licence to construct an NPP. Staff review procedures are described in more detail in subsection 7.2 (ii) a and subsection 8.1 d.

### Updating Design Requirements for New Build

CNSC criteria for evaluating designs of new NPPs are being 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. The CNSC is making progress to bring its design and safety analysis requirements in closer alignment with international standards, in particular with those

promulgated through the IAEA. This has led to the development of new requirements for design (as well as safety analysis; see subsection 14 (i) a for details).

In 2008, the CNSC issued document *Design of New Nuclear Power Plants* (RD-337) to set out its expectations for the design of new, water-cooled NPPs. To the extent practicable, RD-337 is technology-neutral and includes direction concerning:

- establishing the safety goals and objectives for the design
- utilizing safety principles in the design
- applying safety management principles
- designing structures, systems and components (SSC)
- interfacing engineering aspects, plant features, facility layout
- integrating safety assessments into the design process

To a large degree, RD-337 represents the CNSC's adoption of the tenets set forth in IAEA document *Safety of Nuclear Plants: Design* (NS-R-1) and the adaptation of those tenets to align with Canadian practices. RD-337 articulates requirements related to defence-in-depth, use of proven technology, and easily manageable operation of NPPs. The scope of RD-337 goes beyond that of NS-R-1 in addressing the interfaces between NPP design and other topics, such as environmental protection, safeguards, and accident and emergency response planning.

The CNSC is also preparing for the assessment of potential applications for small reactors and NPPs and is updating its regulatory document framework as part of its preparatory efforts. See Annex 7.2 (i) c for a description of the proposed regulatory framework for small reactors.

#### Multinational Design Evaluation Program

The CNSC plays an active role in MDEP, which aims at harmonizing regulatory requirements and regulatory practices and seeks to:

- Enhance multilateral co-operation within existing regulatory frameworks.
- Promote multinational convergence of codes, standards and safety goals.
- Implement MDEP products to facilitate licensing of new reactors, including those being developed by the Generation IV International Forum.

MDEP has representatives from ten countries, with the NEA providing a technical secretariat function.

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

- design-specific safety issues and activities around the AREVA EPR 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

### Vendor Pre-Project Design Reviews

The CNSC has established a vendor-optional process to assess a NPP design 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 Tribunal.

This process is used by a vendor to evaluate, from a business risk perspective, whether its reactor design will be acceptable with respect to Canadian regulatory requirements and expectations. This includes identification of fundamental barriers to licensing a new design in Canada. CNSC is developing staff review procedures to guide the 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.

Phase 1: Based on submissions for the specific design, the submissions should demonstrate to the CNSC that the vendor understands Canadian regulatory requirements and expectations. The scope of submissions is fixed by the CNSC.

Phase 2: Based on submissions for the specific design, the submissions should demonstrate to the CNSC that the proposed design is compliant with RD-337 and related documents. The scope of the review is fixed by the CNSC and involves assessment in 16 specific topical areas.

Phase 3: The vendor, based on feedback received from CNSC in Phase 2, may discuss in more depth, resolution paths for any design issues identified in the Phase 2. The scope of submissions is fixed by the vendor.

A review will assure that the technical considerations have been assessed and therefore does not include 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

At time of this report, the following activities had been completed related to vendor pre-project design reviews.

- Phase 1 and 2 reviews were completed for AECL ACR-1000. The Phase 3 review began and is due for completion in the next reporting period.
- Westinghouse AP1000 Phase 1 review was completed in February 2010.
- Phase 1 review of AECL Enhanced CANDU 600 (EC6) has been undertaken and is due for completion in the next reporting period.
- AREVA EPR Phase 1 review was initiated but put on hold by AREVA.

CNSC has found the vendor pre-project design reviews to be extremely valuable not only as part of preparing for future license 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 CNSC readiness for future licensing activities.

#### Nuclear Code of Conduct for NPP Vendor Countries

Canada is participating in an initiative sponsored by the Carnegie Endowment for International Peace to develop a *Nuclear Code of Conduct* for NPP reactor vendor countries. The purpose of this code of conduct is to develop an agreement on the required support from the reactor vendor for the purchasing country. This is of particular importance for countries that are new to NPP operation.

#### General Provisions to Consider Updated Design Requirements for Currently Operating Reactors

Although new design requirements for NPPs (such as those in RD-337) have been issued in Canada well after the currently licensed NPPs were constructed, various design improvements have been made in the existing NPPs over the years (some specific examples are given in subsection 18 (i)). Design changes are sometimes required to address new standards and other requirements that are added to the operating licences on an ongoing basis (as described under Licence Renewals in subsection 7.2 (ii) d). As well, life extension projects have provided an opportunity to upgrade the existing CANDU designs in alignment with RD-337 and other new standards. Integrated safety reviews (ISR; see subsection 14 (i) c) that are conducted for life-extension projects enable the licensee to determine reasonable and practical modifications to enhance the safety of the facility to a level approaching that described in modern standards.

### **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 concepts:

- conservative design and high quality of construction to minimize abnormal operation or failures
- provision of multiple physical barriers for 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
- supplementing the normal control of the NPP by automatic activation of safety systems or by operator actions
- provision of equipment and procedures to detect failures and back-up accident prevention measures in order 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 the persons, and the protection of 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.

#### Design Criteria and Provisions for Defence-in-Depth in Existing NPPs

Some of the criteria that guided the design of the currently operating NPPs in Canada are described in conjunction with the safety analysis criteria (in subsection 14 (i) a). Specific design criteria and other requirements exist for the special safety systems in the currently operating CANDUs. Special safety systems include the protective shutdown systems, emergency core cooling system, and containment system. Requirements for the special safety systems are described in the following CNSC documents:

- *Requirements for Containment Systems for CANDU Nuclear Power Plants (R-7)*
- *Requirements for Shutdown Systems for CANDU Nuclear Power Plants (R-8)*
- *Requirements for Emergency Core Cooling Systems for CANDU Nuclear Power Plants (R-9)*

Some important examples of implementing the elements of the defence-in-depth approach in the design of the CANDU reactors currently operating in Canada are provided in Annex 18 (i).

During the reporting period, CNSC staff deemed the level of defence-in-depth at all Canadian NPPs to be acceptable.

The following are examples of some design changes at the currently operating NPPs, made during the reporting period, to enhance defence-in-depth by addressing requirements for design basis accidents, as well as conditions predicted for beyond-design basis accidents and severe accidents (severe accident management is described in subsection 19 (iv))

- Powerhouse emergency ventilation systems were installed at Darlington and Pickering A and B.
- Various equipment and components were upgraded at Darlington and Pickering related to environmental qualification for steam exposure during accident conditions.
- OPG is modifying the 37-element fuel bundle design to improve safety margins at its NPPs.
- Control room ventilation was upgraded at Point Lepreau.
- An automated switch from medium to low pressure ECC was installed at Point Lepreau.
- Screens for circulation of ECC were added at all NPPs to decrease the susceptibility of that system to clogging.
- Licensees are significantly upgrading fire protection detection and suppression systems. For example, Bruce Power completed upgrades to transformer deluge systems, turbine sprinkler upgrades, and cable tray fire barrier installations.
- A moderator makeup system was installed at Point Lepreau.
- Passive autocatalytic recombiners are being installed at Bruce A Units 1 and 2, Pickering A Units 1 and 4, Darlington, and Point Lepreau to control hydrogen circulation during severe accidents.

Specific examples of safety enhancements that are relevant to the refurbishment of Point Lepreau are provided in Annex 14 (i) c. Particular design changes that were completed to address the shortcomings witnessed at Pickering during the loss of electricity grid in 2003 are listed in subsection 19 (iv).

A description of the program for feedback of CANDU design-related information to the Canadian NPP industry is included in Annex 19 (vii).

#### Design Criteria for New-Build

The CNSC's regulatory review of an application for a licence to construct will include a review of the clause-by-clause assessment of the proposed design against the requirements in CNSC document *Design of New Nuclear Power Plants* (RD-337). Along the lines of IAEA document NS-R-1, RD-337 requires the concept of defence-in-depth to be applied to all organizational, behavioural, and design-related safety and security activities to ensure that they are subject to overlapping provisions. The application of defence-in-depth is to be applied throughout the design process and operation of an NPP. RD-337 describes five levels of defence-in-depth.

1. Prevent deviation from normal operation and prevent failures of SSCs.
2. Detect and intercept deviations from normal operation to prevent abnormal operational occurrences from escalating to accident conditions and to return the plant to a state of normal operation.
3. Minimize accident consequences by providing inherent safety features, fail-safe design, additional equipment, and mitigating procedures.
4. Ensure that radioactive releases from severe accidents are kept as low as practicable.
5. Mitigate the radiological consequences of potential releases of radioactive materials during accident conditions.

#### **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 to describe the technology employed, and to verify and validate it. These include the safety analysis report and the QA program. As stated in subsection 14 (i) a, the tools and methodologies used in the safety analysis report have to be proven according to national and international experience and validated against relevant test data and benchmark solutions.

CNSC document *Safety Analysis for Nuclear Power Plants* (RD-310), issued during the reporting period, stipulates the selection of computational methods or computer codes, models, and correlations that have been validated for the intended applications.

#### Criteria and Provisions for Existing NPPs

The CANDU design criteria and requirements include design and construction of all components, systems and structures to follow the best applicable code, standard or practice and be confirmed by a system of independent audit.

A Canadian licence requirement for currently operating NPPs is an updated safety analysis report at least once every three years. The safety analysis report must use or incorporate new methodologies, computer codes, experimental data; and research and development findings (see

subsection 14 (i) a for more details). As a result, many of the events in the safety analysis report are often re-analysed in the updated version.

The requirements in RD-310 related to the use of proven computational methods will be gradually addressed for existing NPPs as explained in subsection 14 (i) a.

An example of the application of state-of-the-art technology for CANDU is the research, development and implementation of passive autocatalytic recombiners for all Canadian CANDU NPPs. See Annex 18 (ii) for details.

### Criteria for New-Build

The CNSC's regulatory review of an application for a licence to construct will include a review of the assessment of the proposed design against the requirements for proving engineering practices and qualifying designs in RD-337. RD-337 stipulates that SSCs important to safety are of proven designs and are designed according to appropriate, modern standards. Where a new SSC design, feature, or engineering practice is introduced, adequate safety is proven by a combination of supporting research and development programs, and by examination of relevant experience from similar applications. An adequate qualification program is established to verify that the new design meets all applicable safety expectations. New designs are tested before being brought into service, and are then monitored in service to verify that the expected behaviour is achieved. RD-337 also stipulates that the NPP design draws on operational experience in the nuclear industry and on relevant research programs.

The safety analyses submitted in support of the application will also be assessed against the requirements in RD-310 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 man-machine interface throughout the entire life of the NPP to make sure that stations are tolerant of human errors.

The general consideration of human factors in design, and the application of human factors engineering, is described in subsection 12 b. A more detailed description of the application of human factors engineering to both existing NPPs and new-build is provided in Annex 12 b.

### Provisions in Existing NPPs

The following are two examples of the consideration of human factors and man-machine interface in the design of existing Canadian NPPs.

A high level of automation is incorporated to reduce the risk of operator errors. For instance, automatic actuation of controls or protection systems was developed in order to respond to equipment failure or human error, which could cause a parameter to exceed normal operational limits or a safety system trip set-point. The overall design and the specific design of protection systems make sure that operator intervention is only required when there is sufficient time to diagnose plant conditions and to determine and implement operator actions.

Control room design incorporates strategic placement of the instrumentation and controls used in safety-related operations and accident management. Specific attention is given to device grouping, layout, labelling and device selection. Appropriate attention to human factors and man-machine interface concerns ensures that the information available in the control room is sufficient to diagnose anticipated events or transients and to assess the effects of any actions taken by the operators.

A description of the program for feedback of CANDU operating experience to the Canadian NPP industry is included in Annex 19 (vii).

### Criteria for New-Build

The CNSC's regulatory review of an application for a licence to construct will include a review of the assessment of the proposed design against the requirements related to reliability, operability, and human factors articulated in RD-337.

The requirement in RD-337 to design for reliability includes consideration of common-cause failures and allowances for equipment outages. Design requirements related to single failure criteria for safety groups and failsafe designs for SSCs important to safety are stated. Special considerations are stated for shared instrumentation for safety systems and the sharing of SSCs between reactors.

RD-337 requires an NPP design to include a human factors engineering program plan and utilize proven, systematic analysis techniques to address human factors. The human factors engineering program should address the following:

- Reduce the likelihood of human error as far 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.

RD-337 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 distinction between the functions assigned to operating personnel and to automatic systems is facilitated by systematic consideration of human factors and the human-machine interface. The need for operator intervention on a short time scale is kept to a minimum.

The human factors engineering program should facilitate the interface between the operating personnel and the plant by promoting attention to plant layout and procedures, maintenance, inspection, training, and the application of ergonomic principles to the design of working areas and working environments. The NPP design must facilitate diagnosis, operator intervention, and management of the plant condition during and after anticipated operational occurrences, design basis accidents, and beyond design basis accidents. This facilitation is by adequate monitoring instrumentation, plant layout, and suitable controls for manual operation of equipment.

The human-machine interfaces in the main control room, the secondary control room, the emergency support centre, and in 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.

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.



## 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.

Two programs, Operations and Maintenance, which are relevant to this article, are assessed annually for all licensees in the *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants*. The CNSC Operations program is under the Operating Performance safety area, and the Maintenance program is under the Equipment Fitness for Service safety area. During the reporting period, all the licensees had satisfactory performance in the Equipment Fitness for Service, as well as under the Operating Performance safety area (with a single exception in 2007). See Appendix F for a full definition of the CNSC programs and safety areas (Table F.1) and the performance ratings of the licensees during the reporting period (Table F.2).

### 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 a 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, 7.2 (ii) c, and Articles 17 and 18).

The granting of an initial licence to operate is furthermore based upon an appropriate safety analysis and a commissioning program that demonstrate 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) a and 14 (i) b, respectively. The final safety analysis report that is submitted with an application for a licence to operate a new NPP will be assessed against the requirements in CNSC documents *Safety Analysis for Nuclear Power Plants (RD-310)* and *Design of Nuclear Power Plants (RD-337)*.

The objectives of regulatory oversight of the facility commissioning program are to determine:

- that the commissioning program is comprehensively defined and implemented to confirm that the structures, systems and components (SSCs) important to safety and the integrated plant will perform in accordance with the design intent, safety analysis and applicable licensing requirements
- that the operating procedures covering all operating and abnormal states have been validated to the maximum extent practicable
- that the commissioning and operating staff have been trained and qualified to commission the plant and operate it safely, in accordance with the approved procedures
- that 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

For each phase of commissioning, plant management is expected to establish a set of commissioning control points (CCPs) to achieve a transparent, accountable and effective process to ensure that the defined pre-requisites for the release of each CCP have been formally demonstrated.

Licensing CCPs are regulatory hold points, requiring prior CNSC authorization to proceed further. Non-licensing CCPs are usually treated as CNSC witness points. All applicable non-licensing CCPs must be satisfactorily completed as part of obtaining the release from licensing CCPs.

Details on the conduct of NPP commissioning programs, reactor designer input, and the regulatory oversight of commissioning are provided in Annex 19 (i).

See subsection 7.2 (ii) d for additional details on information that an applicant is required to submit with an application for a licence to operate.

## **19 (ii) Operational Limits and Conditions**

### **19 (ii) a Identification of safe operating limits**

The requirement for NPP licensees to stipulate operating conditions is stated in clause 6 (b) of the *Class I Nuclear Facilities Regulations*. Operating limits for Canadian NPPs that have the greatest impact on safety are identified in the operating policies and principles (OP&P; see subsection 9 c) documentation for Canadian NPPs. Changes to these limits that may negatively



impact safety require appropriate justification by operations support staff and approval by the CNSC.

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 subsection 19 (iv)), as well as in the OP&Ps.

The full set of requirements for safe operation of a CANDU NPP includes the following:

- requirements on special safety systems and safety-related standby equipment or functions (e.g., setpoints and other limiting parameters, and 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 etc. 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 and operating states. However, it is not feasible to analyse 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.

#### **19 (ii) b Safe operating envelope project**

The purpose of the safe operating envelope (SOE) project is to more clearly define the safe operating limits for Canadian NPPs, so that they are readily measurable by operations staff. One of the main outputs was the publication by COG of industry principles and guidelines for SOE that integrate best practices and operating experience from Canadian NPPs. More background on this project is provided in the fourth Canadian report.

One of the actions on Canada from the Third Review Meeting was to continue the SOE projects at the NPPs.

During the reporting period, a joint industry-CNSC working group was formed to facilitate a more consistent alignment of the licensees' SOE projects with the COG guidelines. The working group's objective is to build on the industry's current approach to defining and implementing the SOE, to enhance the clarity of operating limits and conditions, and to outline a transition from the current to a future state. Work is underway to convert the SOE guidelines into a CSA standard during the next reporting period. It is anticipated that there will be only minor modifications to principles and requirements as stated in the COG document. The CNSC has representation on the CSA technical sub-committee responsible for producing the new standard.

### Operational Safety Requirements for Bruce Power and OPG

OPG and Bruce Power are in various stages of preparation and revision of operational safety requirements (OSR) documents for SOE systems. These documents provide a comprehensive list of the safe operating limits for a given SOE system. The documents provide a definitive and maintainable link between safety analysis and the OSRs. A gap analysis process ensures that the SOE safe operating limits are mapped to station operating documentation. Additional effort is being undertaken to ensure that the links to the documentation are kept up to date.

In the next reporting period, OPG is planning to complete revisions to OSR reports and instrument uncertainty calculation reports and to define SOE compliance tables, which are appended to OSR reports. The implementation of SOE parameter requirements into station operating documentation should also be completed for Pickering A and B and Darlington in the next reporting period. Discrepancies are being dispositioned using normal change control processes, such as engineering change control, document revision, and update of the safety analysis report. To date, no serious discrepancies were discovered.

During the reporting period, Bruce Power issued the SOE governing documents and compliance framework, and has completed the OSR reports and instrument uncertainty calculation reports on the highest-priority systems for Bruce A and B. The current focus on SOE is the implementation activities towards full program implementation in the next reporting period.

### Point Lepreau

The Point Lepreau SOE project comprises two phases. The first phase of the SOE project, to review and redefine the SOE for special safety systems, was completed during the reporting period. The activities included:

- revising SOE basis documents for ECC, shutdown systems 1 and 2, and writing a basis document for containment
- documenting and resolving differences between the SOE and existing operational documentation
- redesigning and revising the safety system impairments manual
- preparing a technical basis document that provides operations with the rationale for impairments limits, based on SOE implementation

The second phase will follow through with application to other systems important to safety, as identified by the PSA. In addition to those systems, the licensee will also examine the higher-level system parameters that have a direct impact on the functionality of special safety systems, but are not directly associated with them. Work on the SOE definition for the second phase is nearing completion, and implementation began in early 2010; the completion is targeted for the next reporting period.

### Hydro-Québec

Hydro-Québec will establish an action plan to more clearly define the SOE, following the issue of the CSA document. The action plan is expected to be implemented over a period of approximately 30 months.

Concurrently with the industry's activities, the CNSC initiated an SOE project for overseeing CNSC and industry SOE-related work. The first phase of this project was completed in 2009, by developing and communicating the CNSC's definition of SOE to the licensees. The second phase, to be completed in the next reporting period, includes participation in the development of the CSA standard on SOE and monitoring of the industry's implementation of the SOE programs. The third phase, regulatory implementation, is also planned for the next reporting period.

Suggestion S7 from IRRS Mission

*“The CNSC should complete the project for Safe Operating Envelope (SOE) and consider including its results into the licence limiting conditions for operation (LCOs) as an extension to OP&Ps for nuclear power plants.”*

The CNSC has initiated a SOE project which aims to establish regulatory requirements related to the development, by NPP licensees, of an SOE for their respective NPPs. Phase 1 comprises the development of an SOE definition, composition and objective. Phase 2 comprises the development of an SOE methodology position paper.

### 19 (iii) Procedures for Operation, Maintenance, Inspection and Testing

Operation, maintenance, inspection and testing of systems, equipment and components at NPPs are conducted in accordance with approved governance and procedures. The governance and procedures are incorporated in various licensee programs (examples are provided in Appendix C) within the structure of the NPP's management system (see subsection 13 a). The governance defines the organizational and administrative requirements to establish and implement preventive, corrective and predictive maintenance, periodic inspections, tests, repairs, replacements, training of personnel, procuring spare parts, providing related facilities and services, and generating, collecting and retaining operating and maintenance records. All NPP operating licences contain conditions that specify the requirements for these activities.

The CNSC document *Maintenance Programs for Nuclear Power Plants* (S-210) was issued in 2007 and added to the operating licences that were renewed during the reporting period. S-210 sets the requirements for policies, processes and procedures that provide direction for maintaining the SSCs of the NPP. The range of maintenance activities specified includes monitoring, inspecting, testing, assessing, calibrating, servicing, overhauling, repairing, and replacement of parts. The purpose of these activities is to ensure that the reliability and effectiveness of all equipment and systems continue to meet the standard claimed in the licensing basis.

A condition in all NPP operating licences establishes reliability program requirements by reference to CNSC document *Reliability Programs for Nuclear Power Plants* (S-98 Rev 1). S-98 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, modeling, 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) b), deterministic analyses (see subsection 14 (i) a), and expert panels.

Operations are governed by the OP&Ps for each NPP, which set requirements for the maintenance and testing procedures for special safety systems. These procedures are designed to make sure that no safety function is ever compromised by maintenance activities. For example, safety system testing is required at a frequency that demonstrates that each safety function is operating correctly and meets availability limits (typically 99.9%). Each component of a special safety system is subject to a regular functional test.

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 that are 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 subsection 19 (vii) for more details).

Specific requirements for testing to confirm the availability/functionality of safety and safety-related systems are described in subsection 14 (ii) a.

Several improvements were implemented by the NPP licensees during the reporting period that will positively impact various aspects of operation, maintenance, inspection and testing. OPG converted major process systems to digital control at Pickering and Darlington, and updated the control computer and shutdown system computer hardware and software. Improvements to plant surveillance hardware and software were also implemented, to improve component and system surveillance and trending capabilities. An improved gaseous fission product monitoring system is being installed at Darlington, to help identify and locate failed fuel for timely removal from the core. Improvements to fuel handling are also being implemented at Darlington, which will improve the reliability of the fuel handling system and improve reactivity management. Bruce Power upgraded the sample cabinet for shutdown system 2 at Bruce B, to eliminate radiological hazards associated with routine sampling activities.

#### **19 (iv) Procedures for Responding to Operational Occurrences and Accidents**

It is recognized that the consequences of reactor accidents can be minimized by sound accident management onsite and offsite. This is achieved by developing operating procedures in advance, to assist and guide operators in responding to accidents.

Procedures used by NPP staff during routine operation of the NPP and its auxiliary systems are located in the operating manuals. There are typically two categories of procedures within the system operating manual:

- system-based procedures that control operation of systems during normal and abnormal operations, and system start-up and shutdown
- integrated procedures that coordinate major evolutions such as station start-up and shutdown

Procedures are also established for responding to anticipated operational occurrences and accidents.

The response to anticipated operational occurrences and accidents is controlled through a hierarchical system of NPP procedures. Although procedure variations exist between NPPs, the generic structure of this system is summarized as follows:

- operating manuals
- alarm manual
- abnormal incident manual
- impairments manual
- radiation protection manual (or radiation protection directives)

Alarm manual procedures provide the operations staff with information regarding alarm functions. Typical information provided within these procedures includes set points, probable cause of alarm, pertinent information, references and operator response.

Abnormal incident manual procedures provide information to the operations staff that may be helpful following safety system impairment, process system failure or a common mode event. At OPG, for example, there are three categories of procedures within the abnormal incident manual:

- abnormal state of safety system procedures
- emergency operating procedures
- critical safety parameter monitoring procedures

At other utilities, abnormal plant operating procedures and emergency operating procedures are issued as separate manuals.

The procedures for abnormal state of safety systems direct compensatory actions to be taken when a safety system is impaired or unavailable. The emergency operating procedures direct operator actions during accident conditions, and are designed to restore the NPP to a safe condition and to protect the health and safety of NPP personnel and the general public. Critical safety parameter procedures provide augmented monitoring of critical NPP operating parameters during accident conditions and provide a support feature to the emergency operating procedures (see subsection 16.1 b for onsite emergency procedures).

Impairment manual procedures specify actions to be taken when there are indications that operation is getting close to, or outside of, the safe operating limits.

Radiation protection manual procedures are provided, to protect the safety of the operators and the general public in the event of a significant radiation incident. These procedures:

- direct event classification and categorization
- make provisions for offsite notification
- direct protective actions and monitoring during accident conditions

An operating licence condition specifies the minimum staff complement that must be present at the NPP at any time. The CNSC includes this requirement, to make sure that there is always a sufficient number of appropriately qualified staff available to respond to an emergency (for details, see Annex 11.2 a).

The fundamental elements of licensee procedures for responding to anticipated occurrences and events were unchanged during the reporting period. In general, and as described in the second and third Canadian reports, licensees have developed and continue to maintain operating procedures for dealing with operational occurrences, situations and events. Such procedures include determination of root causes and effecting remedial and corrective actions, commensurate with the situations.

The most safety-significant operational events that occurred at Canadian NPPs during the reporting period are listed in Appendix D. 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 any deficiencies and preventing recurrence. None of these 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.

Events that are reported to the IAEA Nuclear Event Web-based System (NEWS) are rated as per the International Nuclear Event Scale (INES), to ensure that the safety significance of the event is understood at the international level. During the reporting period, two Canadian events were reported to the NEWS, and were each given a preliminary INES rating of "0".

#### Severe Accident Management Guidelines

Challenge C-3 for Canada from the Fourth Review Meeting  
*"Plan & implement SAMGs, and plan and conduct validation exercises"*

The NPP operations response to a severe accident would be to declare a general emergency at the NPP and activate the onsite emergency response. Changes to facilitate severe accident management have focused on the incident command organization at the facility, with an emphasis on providing the essential safety and mitigation functions of 'control, cool and contain' by any capable and available means.

The implementation of severe accident management guidelines (SAMG) at NPPs in Canada is in various stages of completion at the different facilities. The measures to be implemented differ somewhat, depending on the location and nature of the NPP, as some are single-unit facilities in relatively remote rural locations, and others are multi-unit facilities close to major urban centres.

Offsite emergency response measures (described in subsection 16.1 c) are the responsibility of the provincial government in which the NPP is located, and differ in the measures that would be implemented. In general, offsite emergency response plans are comprehensive enough to encompass the management of severe accident response; exercise scenarios have often tended to focus on the more severe events, in order to require testing of the full scope of provincial plans. Most changes are anticipated in relation to facilitating implementation of onsite severe accident management by the NPP licensees.

Progress on implementing SAMG at each of the NPPs during the reporting period is described in Annex 19 (iv). The CNSC is monitoring the rollout of SAMG at each NPP, and observing some of the validation exercises.

Examples of design changes that have been made at the NPPs to address conditions that could occur during severe accidents are described in Annex 14 (i) c (specific to Point Lepreau).

#### Follow-up at Pickering to the Loss of Electricity Grid (Blackout) of August 14, 2003

As reported in the third Canadian report, the follow-up to the loss of the electricity grid (blackout) on August 14, 2003, at Pickering identified that some of the design and operation assumptions could be challenged by such an event. In particular, the high-pressure ECC system, which is common to both Pickering A and B, was unavailable for 5.5 hours because of loss of power to the high-pressure pumps. In addition, the emergency high-pressure service water system restoration for all Pickering B units was delayed because of low suction pressure supplying the emergency high-pressure service water pumps. During that time, there was no fire water available to Pickering B. During the loss of offsite power, the three units at Pickering B remained in a hot, pressurized state with heat removal through the steam generators via thermo-syphoning. The CNSC requested that OPG identify potential changes in facility design, analysis, testing and maintenance to mitigate future occurrence of the results observed.

To address the need for power to enable the cool-down of the units, a major design change was initiated at Pickering, in order to install an auxiliary power system. While the auxiliary power system was being installed, a temporary 22 MW remotely-switched emergency power generator was installed to provide power to the high-pressure ECC pump in the absence of the electricity grid.

The auxiliary power system has two 45 MW combustion turbine units, to supply power during a blackout by delivering it directly to the NPP electrical system. Design of the auxiliary power system power plant was completed in 2006, and the project was declared available for use in 2007.

Modifications have been completed to the turbine-generator control systems, to improve the likelihood of the units continuing to operate after a similar event.

The remaining issues from the loss of the electricity grid in 2003 were related to service water supply capacity, service water surveillance and maintenance, and fire water supply capacity. OPG has improved the service water system capacity, by overhauling and improving the performance of the service water pumps. OPG has also completed and submitted the operational

safety requirements document for the service water systems. This document showed that the service water systems are able to meet all their capability requirements.

### **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.

Article 11 addresses licensee financial and human resources, which are planned throughout the NPP's life and include required improvements 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 (e.g., AECL) that include research, engineering, analysis, assessment, maintenance, inspections and design support. The CANDU research and development (R&D) program, which supports the operating NPPs, is described in Appendix E.

Canadian NPP licensees have 'smart buyer functions', to assure that the services rendered to them serve the purpose and meet the relevant requirements. In short, a smart buyer is a recipient organization that knows what it will likely receive, its implications, the methodology used by outside contractors to arrive at certain position, and how it will be managed both internally and by the CNSC. For example, the OPG smart buyer function establishes a number of key attributes to enable recognition of the quality of outputs provided by outside organizations as it 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 OPG station design and operation
- ongoing, positive relationships with internal stakeholders
- excellent written and oral communication skills
- ability to provide leadership on technical issues within the Canadian nuclear industry

AECL and NPP licensees utilize a design authority function to ensure that the integrity of approved designs and the design process is maintained. The design authority at AECL is executed by the chief engineer. The design authority encompasses overall responsibility for the design process, approval of design changes, and the responsibility for ensuring that the requisite knowledge of the reference design is maintained as defined and implemented in the management system. The scope of accountability includes ensuring that:

- a knowledge base of relevant aspects of the facility and products is established and kept up to date while taking into account experience and research findings
- all design information that is 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 interface 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 AECL procedures

### **19 (vi) Reporting Incidents Significant to Safety**

Station condition records or event reports, submitted by the licensees in accordance with the condition in their operating licences that cite CNSC document *Reporting Requirements for Operating Nuclear Power Plants (S-99)*, are the primary source of information. These reports 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 CNSC in a timely manner and in accordance with the requirements of S-99. 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.

Canada is committed to report to the International Reporting Systems, operated by both the IAEA and the NEA, on significant events that occur in Canadian NPPs. Canada appointed a member of the CNSC staff as a national coordinator, to collect and analyse information on events occurring in Canada, and to transmit them to the IAEA. Actions taken in Canada in response to address events reported internationally are presented annually by Canada through its delegates to the appropriate fora, such as the IAEA International Reporting System technical committee, and the NEA Working Group on Operating Experience.

Issues arising from 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 early notification reports, which are submitted to the Commission Tribunal members. Guidance for screening is being developed.

At OPG, the significance of discoveries other than incidents (e.g., unexpected degradation of equipment, management issues raised through various means including World Association of Nuclear Operators peer reviews, design weaknesses) is rated using criteria in the Corrective Action Program.

### **19 (vii) Operational Experience Feedback**

Good Practice G-5 for Canada from the Fourth Review Meeting  
*“CANDU Owners Group, CANDU Senior Regulators Group, WANO, OPEX information exchange approach including regular contact conferences”*

Licensees conduct analysis and trending of events with relatively small safety significance, in order to help prevent the occurrence of events with more significant consequences. A description of the programs to collect and analyze information on operating experience is provided in Annex

19 (vii). The annex also contains information on the collection and dissemination of design-related information by AECL.

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. They use this information to determine the appropriate course of action and assess the licensee's submissions regarding the particular event.

CNSC staff incorporates results of event 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 that they are completed expeditiously.

CNSC inspection teams consult the operating experience in the CERTS database (described in subsection 7.2 (iii) b) when planning strategies for their audits and in identifying problem areas in operation or maintenance, such as procedural non-compliance, procedural deficiencies and use of non-standard components. Similarly, assessments conducted by CNSC specialists often utilise the operating experience recorded in this database.

### **19 (viii) Management of Spent Fuel and Radioactive Waste on the Site**

#### Responsibility

The Government of Canada has established a radioactive waste policy framework, to ensure the safe-management of spent fuel and radioactive wastes. Primary responsibility for the management and long-term storage of radioactive waste and spent fuel rests with licensees.

#### Operations

Canadian NPPs manage waste using methods similar to those practiced in other countries. Primary emphasis is placed on minimization, volume reduction, conditioning and interim storage of the waste, since disposal facilities are not yet available.

A key principle when making regulatory decisions concerning the management of radioactive waste, as outlined in CNSC regulatory policy *Managing Radioactive Waste* (P-290), is that generation of radioactive waste should be minimized to the extent practicable, by implementing design measures and operating and decommissioning practices.

The Canadian nuclear industry minimizes waste through the following practices:

- material control procedures to prevent materials from unnecessarily entering into radioactive areas
- enhanced waste monitoring capabilities to reduce inclusion of non-radioactive wastes in radioactive wastes
- use of launderable personal protective equipment, instead of single-use items
- improvements to waste handling facilities
- employee training and awareness

Reusing personal protective equipment has helped reduce the potential waste being generated during the refurbishment of NPPs. Compaction of replaced components has also helped to significantly reduce the volume of waste generated during refurbishment.

All waste produced at NPPs is segregated at its point of origin as contaminated or non-contaminated. Low-level and intermediate-level contaminated wastes are further sorted into distinct categories, such as the following:

- can be incinerated
- can be compacted
- cannot be processed, to further reduce its volume

Further sorting of the waste helps to facilitate subsequent handling, processing and storage.

### Radioactive Waste Management

Because there are no disposal facilities in Canada, all radioactive waste from NPPs is in interim storage. Radioactive wastes resulting from reactor operations are stored onsite or offsite in above- or below-ground engineered structures. Prior to storage, the volume of the wastes may be reduced by incineration, compaction, shredding or baling. In addition, there are facilities for the decontamination of parts and tools, laundering of protective clothing, and the refurbishment and rehabilitation of equipment.

NPP licensees have instituted methods to recover storage space after sufficient radioactive decay or reclaiming existing storage space through further compaction (super compaction) and/or segregation.

It is possible to retrieve all stored radioactive waste.

As for all nuclear activities, the facilities for handling radioactive waste must be licensed by the CNSC, and conform to all pertinent regulations and licence conditions. The waste management objective throughout the industry – from mines to reactors – is the same, which is to control and limit the release of potentially harmful substances into the environment. The CNSC staff inspects all licensed facilities, to confirm the achievement of these objectives. Further information on Canada's provisions for low- and intermediate-level radioactive waste and spent fuel can be found in the *Third 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 2008. This report is available on the CNSC and IAEA Web sites.

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## **APPENDICES**



## Appendix A Relevant Web Sites

<b>Document or Organization</b>	<b>Web site</b>
<i>Nuclear Safety and Control Act</i>	<a href="http://laws.justice.gc.ca/en/N-28.3/index.html">http://laws.justice.gc.ca/en/N-28.3/index.html</a>
<i>Canadian Environmental Assessment Act</i>	<a href="http://www.ceaa-acee.gc.ca/013/intro_e.htm">http://www.ceaa-acee.gc.ca/013/intro_e.htm</a>
<i>General Nuclear Safety and Control Regulations</i>	<a href="http://laws.justice.gc.ca/eng/SOR-2000-202/index.html">http://laws.justice.gc.ca/eng/SOR-2000-202/index.html</a>
<i>Class I Nuclear Facilities Regulations</i>	<a href="http://laws.justice.gc.ca/eng/sor-2000-204/index.html">http://laws.justice.gc.ca/eng/sor-2000-204/index.html</a>
<i>Radiation Protection Regulations</i>	<a href="http://laws.justice.gc.ca/eng/SOR-2000-203/index.html">http://laws.justice.gc.ca/eng/SOR-2000-203/index.html</a>
Atomic Energy of Canada Limited (AECL)	<a href="http://www.aecl.ca">http://www.aecl.ca</a>
Bruce Power Inc.	<a href="http://www.brucepower.com">http://www.brucepower.com</a>
Canadian Nuclear Safety Commission (CNSC)	<a href="http://www.nuclearsafety.gc.ca">http://www.nuclearsafety.gc.ca</a>
Canadian Environmental Assessment Agency	<a href="http://www.ceaa-acee.gc.ca">http://www.ceaa-acee.gc.ca</a>
CANDU Owner's Group (COG)	<a href="http://www.candu.org">http://www.candu.org</a>
CANTEACH	<a href="http://canteach.candu.org">http://canteach.candu.org</a>
Health Canada (HC)	<a href="http://www.hc-sc.gc.ca">http://www.hc-sc.gc.ca</a>
Hydro-Québec	<a href="http://www.hydroquebec.com">http://www.hydroquebec.com</a>
International Atomic Energy Agency (IAEA)	<a href="http://www.iaea.org">http://www.iaea.org</a>
Natural Resources Canada (NRCan)	<a href="http://www.nrcan-rncan.gc.ca">http://www.nrcan-rncan.gc.ca</a>
New Brunswick Power Nuclear (NBPN)	<a href="http://www.nbpower.com">http://www.nbpower.com</a>
Ontario Power Generation (OPG)	<a href="http://www.opg.com">http://www.opg.com</a>
University Network of Excellence in Nuclear Engineering (UNENE)	<a href="http://www.unene.ca">http://www.unene.ca</a>
University of Ontario Institute of Technology	<a href="http://www.uoit.ca/">http://www.uoit.ca/</a>





## Appendix B

### List and Status of Nuclear Power Plants in Canada

Reactor	Licensee	Gross Capacity (MW)	Construction Start	First Criticality	Operating Status
Bruce A, Unit 1	Bruce Power	904	Jun. 1, 1971	Dec. 17, 1976	Defuelled Dec. 31, 1997; refurbishing
Bruce A, Unit 2	Bruce Power	904	Dec. 1, 1970	Jul. 27, 1976	Defuelled Oct. 8, 1995; refurbishing
Bruce A, Unit 3	Bruce Power	904	Jul. 1, 1972	Nov. 28, 1977	Operating
Bruce A, Unit 4	Bruce Power	904	Sep. 1, 1972	Dec. 10, 1978	Operating
Bruce B, Unit 5	Bruce Power	915	Jul. 1, 1978	Nov. 15, 1984	Operating
Bruce B, Unit 6	Bruce Power	915	Jan. 1, 1978	May 29, 1984	Operating
Bruce B, Unit 7	Bruce Power	915	May 1, 1979	Jan. 7, 1987	Operating
Bruce B, Unit 8	Bruce Power	915	Aug. 1, 1979	Feb. 15, 1987	Operating
Darlington, Unit 1	OPG	935	Apr. 1, 1982	Oct. 29, 1990	Operating
Darlington, Unit 2	OPG	935	Sep. 1, 1981	Nov. 5, 1989	Operating
Darlington, Unit 3	OPG	935	Sep. 1, 1984	Nov. 9, 1992	Operating
Darlington, Unit 4	OPG	935	Jul. 1, 1985	Mar. 13, 1993	Operating
Gentilly-2	Hydro-Québec	675	Apr. 1, 1974	Sep. 11, 1982	Operating
Pickering A, Unit 1	OPG	542	Jun. 1, 1966	Feb. 25, 1971	Restarted in 2005
Pickering A, Unit 2	OPG	542	Sep. 1, 1966	Sep. 15, 1971	Progressing toward safe storage state
Pickering A, Unit 3	OPG	542	Dec. 1, 1967	Apr. 24, 1972	Progressing toward safe storage state
Pickering A, Unit 4	OPG	542	May 1, 1968	May 16, 1973	Operating
Pickering B, Unit 5	OPG	540	Nov. 1, 1974	Oct. 23, 1982	Operating
Pickering B, Unit 6	OPG	540	Oct. 1, 1975	Oct. 15, 1983	Operating
Pickering B, Unit 7	OPG	540	Mar. 1, 1976	Oct. 22, 1984	Operating
Pickering B, Unit 8	OPG	540	Sep. 1, 1976	Dec. 17, 1985	Operating
Point Lepreau	NBPN	680	May 1, 1975	Jul. 25, 1982	Defuelled: May 10, 2008; refurbishing



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## **Appendix C**

### **Examples of Descriptions and Plans Required to Support an Application to Renew a Nuclear Power Plant Operating Licence**

- Chemistry control program
- Community information program
- Decommissioning plan and financial guarantees
- Design description
- Design engineering program; including
  - engineering change control program
  - commissioning program
  - configuration management program
- Effluent and environmental monitoring program
- Environmental protection program
- Emergency preparedness program
- Environmental qualification program
- Fire protection program
- Human factors program
- Maintenance program, including periodic and in-service inspection program
- Nuclear substance control program
- Occupational health and safety program
- Operations program
- Organization staffing and training program
- Organizational management structure, including:
  - documents describing the organizational structure, roles and responsibilities of organizational units and management
  - documents governing the day to day operation and conduct of the organization
- Performance engineering program, including:
  - systems, component and equipment technical surveillance and reporting programs
  - aging management program
- Quality assurance program, including corrective action and operating experience programs
- Radiation protection program
- Reliability program, including safety and safety-related systems
  - operability tests
  - supporting reliability analyses
- Safeguards program
- Safety analysis report and any additional safety analyses and assessments
- Security program
- Station improvement plans
- Waste management program



## Appendix D

### Significant Events during Reporting Period

NPP/Date/Topic	Description	Corrective Action by Licensee	Regulatory Action by CNSC
Bruce B Units 5 and 7  August - October 2007  Containment Isolation on High Activity	<p>A defective fuel bundle that was removed from the reactor was discovered to have multiple weld failures between the fuel sheath and the endcaps. Examination determined that the weld failures had opened up significantly when the bundle was pushed into the fueling machine during de-fueling. However, while the bundle was in the reactor, the shut-down limit for total iodine in the heat transport system was never approached. Two months later, a second defective bundle with two weld defects was found. The iodine levels in all operating Bruce Power reactors were always well below the shut-down limit.</p>	<p>After the first defective fuel bundle was discovered, Bruce Power quarantined approximately 15,000 fuel bundles, and identified approximately 100 “high risk” bundles. Investigation by the licensee and the fuel bundle manufacturer determined that the two bundles were manufactured on the same day. Bruce Power took the precaution to monitor all bundles produced since November 2005. Post-irradiation examinations were conducted to determine the root cause. There was no increased risk to the public or workers from the event.</p> <p>The manufacturer also conducted an extensive investigation and took corrective measures.</p> <p>Bruce Power shared OPEX with other licensees. In response, Point Lepreau also quarantined its fuel, to assess the potential for similar failures. Gentilly-2 conducted an extensive review of its inventory, both irradiated and non-irradiated, and</p>	<p>CNSC staff performed a special inspection of Bruce Power’s fuel management program, and determined that the measures taken by Bruce Power were acceptable.</p>

NPP/Date/Topic	Description	Corrective Action by Licensee	Regulatory Action by CNSC
		concluded there were no defective bundles on site. Gentilly-2 also increased its fuel sampling for priority loading.	
<p>Pickering A Units 1 and 4</p> <p>May 2007</p> <p>Shutdown due to Potential Loss of Electrical Power</p>	<p>During the inspection and repair of steam-protected rooms, a problem was found with a modification made in 2005, in which the power supply for the ventilation of some steam protected rooms had been removed. Without this ventilation, the availability of the inter-station transfer bus (ISTB) could not be guaranteed in the event of a main steam line break. The ISTB provides power from Pickering B to essential equipment after a main steam line break in the Pickering A powerhouse. Under worst-case accident conditions, the ISTB did not have the load carrying capacity required, and had an unacceptably large voltage drop at the load end.</p>	<p>OPG shut down Pickering A, while they designed and installed temporary modifications to restore the functionality of the ISTB. Longer-term, permanent changes were installed in 2010. Units 1 and 4 were approved for restart once the temporary modifications were completed.</p> <p>Since 2007, OPG has made a number of improvements to address the root causes of the ISTB event, including those related to safety culture. A number of self assessments have also been performed.</p>	<p>CNSC staff reviewed the engineering design and operational changes to restore ISTB function, OPG's Root Cause Investigation Report, and OPG's Extent of Condition reports (used to determine how widespread the concerns might be). CNSC staff made 15 recommendations, which OPG has addressed. CNSC staff conducted onsite verification activities to determine the effectiveness of the corrective actions in October 2009..</p>
<p>Point Lepreau</p> <p>September 2007</p> <p>Liquid Zone Control Indication Upset</p>	<p>A liquid zone control system (LZCS) level indication upset (erroneous indication) caused a bank of adjuster rods to drive out of the reactor core. The maneuver was initiated under the control of the reactor regulating system, when the average zone level indication erroneously dropped to below 20%. The change of reactivity mechanism configuration resulted in localized</p>	<p>The cause of the LZCS indication upset was attributed to instability in the LZCS balance header pressure, resulting in false low-level indications from the LZCS instrumentation. The licensee:</p> <ul style="list-style-type: none"> <li>• replaced the defective components</li> <li>• revised the inspection and preventative maintenance plans for balance header pressure controllers</li> </ul>	<p>CNSC staff agreed with the licensee's assessment of the event and the corrective action plan.</p>

NPP/Date/Topic	Description	Corrective Action by Licensee	Regulatory Action by CNSC
	reactor power increases, which actuated shutdown systems 1 and 2.	<ul style="list-style-type: none"> <li>• identified controllers on other safety significant systems, and performed the necessary inspection and preventative maintenance on those controllers</li> <li>• shared the OPEX with industry</li> </ul>	
Darlington Unit 4  July 2008  Shutoff Rods Dropped in Core	During routine maintenance on the “even” bank of shutoff rod clutches, power to the clutches (which keep the rods suspended and poised) was transferred to the backup power supply. The backup power supply subsequently failed, causing the “even” bank of shutoff rods for shutdown system 1 to drop into the core.	The main control room operator tripped shutdown system 1 and the remainder of the shutoff rods (“odd” bank) dropped into the core, shutting down the reactor. The fuse holder cap for the backup power supply was identified as the likely cause of the event. A clip was degraded and no longer provided good contact between the fuse and the fuse holder cap.	CNSC staff was satisfied with OPG’s response to this event.
Pickering B Unit 7  April 2008  Decrease in Gadolinium Concentration	The reactor was place in moderator-drained guaranteed shutdown state (GSS), following an unexplained decrease in gadolinium concentration that occurred while the unit was in over-poisoned GSS. An investigation into the event determined that elevated CO <sub>2</sub> levels from a small annulus gas leak led to the formation of insoluble gadolinium oxalate in the calandria.	The licensee requested rod-based GSS, and replaced the leaking calandria tube, returned the gadolinium concentration levels to normal, and returned the unit to service.	CNSC staff reviewed OPG’s submissions and approved the use of rod-based GSS to evaluate the condition and effect the necessary repairs.
Gentilly-2	A leak-before-break detection (LBBD) system is required on the steam lines	LBBD is now fully available. A significant event analysis and a	The event was presented to the Commission Tribunal at the August

NPP/Date/Topic	Description	Corrective Action by Licensee	Regulatory Action by CNSC
April 2008 Steam Leak Detection and Location System	inside the reactor building. This system was to be commissioned in 2005; however, the commissioning activity was never completed, and the LBB system has remained unavailable. CNSC staff discovered this licence non-compliance in 2008.	comprehensive event report were produced. All necessary measures have been put in place to resolve the problem.	21, 2008, Commission Meeting. A follow-up by CNSC Staff concerning this event was subsequently conducted.
Gentilly-2 October 2009 Trip of Shutdown System 1 on Low Heat Transport System Flow	<p>During the synchronization of one of the four gas turbines on the electrical grid, a defect caused the activation of an emergency power surge breaker, which in turn activated three other breakers that feed one of the two station transformers. A slow transfer from the main to standby grid transformer led to low flow of heat transport coolant, which caused the trip of shutdown system 1.</p> <p>A transfer of the electric current to the backup transformer reestablished power to the station. The manual release of the turbine was carried out 12 seconds later. This event did not have any negative impact on the public, the environment or workers. The station safety systems responded appropriately, and the station was never at risk.</p>	<p>A detailed event report was produced to address all problems related to this event.</p> <p>The circuit breaker activation and quick turbine release are now subject to an on-going investigation by Hydro-Québec.</p>	The event was presented to the Commission Tribunal at the November 5, 2009, Commission Meeting. The findings and resultant corrective measures put in place were accepted.
Darlington	During maintenance of the emergency service water system, lake water was	OPG determined that no more than 210,000 litres of water from the IWST	CNSC staff reviewed OPGN actions and informed the



NPP/Date/Topic	Description	Corrective Action by Licensee	Regulatory Action by CNSC
December 2009  Water Release	inadvertently pumped to the injection water storage tank (IWST), which is part of the emergency core coolant (ECC) system. The IWST overflowed, partly to a sump inside the building and partly to grade, from where the water flowed to yard drains that discharge to Lake Ontario. The IWST contains demineralized water, which is treated with hydrazine for corrosion protection. It also contains low levels of tritium, as a result of testing the injection valves to the four reactors.	was released to the yard, some of which passed to the lake. The remainder is in the IWST and the ECC equipment room sump, inside the building. Drains in the yard were covered to prevent further release to the lake. OPG informed the CNSC, the Ontario Ministry of Environment and local authorities of the event.  Samples taken at local water treatment plants over the following three days showed no tritium levels above background. Samples taken from different locations in the yard predicted that tritium in the water released was equivalent to 0.003% of the Derived Release Limit (DRL).	Commission Tribunal. No further actions were necessary.
Bruce A Unit 1  November 2009  Alpha Contamination	Workers conducting a routine airborne survey in the vault at Unit 1, which was undergoing refurbishment, detected elevated levels of alpha contamination. A team was assembled to determine how many workers were involved and which individuals would require alpha dosimetry. A total of 563 workers were assessed for exposure; of these, 192 workers were estimated to have exceeded 1 mSv exposure (thus requiring dosimetry), including 92 workers who may have exceeded 2	Bruce Power took immediate measures to identify and contain the contamination. Work in the vault was stopped until cleanup of the contamination was complete.  Workers potentially affected by the incident were removed from radioactive work until additional information regarding the exposures was obtained.  Increased monitoring of affected workers and a root cause investigation continues.	CNSC staff conducted an inspection, and concluded that Bruce Power took appropriate action to contain the contamination and protect the health and safety of workers.  As of the end of the reporting period, the CNSC continued to monitor the situation and Bruce Power's remedial activities. There was no risk to the public or the environment. All regulatory

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NPP/Date/Topic	Description	Corrective Action by Licensee	Regulatory Action by CNSC
	<p>mSv, and 27 workers who may have exceeded 5 mSv.</p> <p>By March 2010, bioassay sample analysis of the potentially most affected workers indicated that the doses received were well below regulatory limits. Bioassay sample analysis on other potential workers is underway. Final results are expected in June 2010.</p>		<p>requirements, including reporting requirements, were met.</p>

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## Appendix E

# Nuclear Safety Research in Canada Related to Nuclear Power Plants

### E.1 Introduction and Context

Canada shares the view that nuclear safety research is important in supporting safe plant design and operation. In Canada, it is the responsibility of the applicant, with the aid of the plant designer, to provide adequate safety justification in order to obtain licensing approval. Fulfilling this responsibility includes provision of adequate experimental data to support analytical models and safety analyses. As practice shows, ongoing experimental research is needed for operating plants, as well as for plant life extension and new reactors.

The need for experimental research was further emphasized by a recently completed project by the CNSC that led to the development of a risk-informed position on outstanding safety issues for CANDU reactors (see Article 14 (i)). This risk-informed position is of particular importance to focus research efforts on safety-significant areas, and to facilitate the development of plant-specific safety improvement programs (to support plant re-licensing and life extension projects) or the reviews of new reactor designs.

Research and development (R&D) supporting NPPs in Canada is conducted by many organizations, including AECL, COG, utilities, universities, and private-sector laboratories. The following subsections describe the key elements of R&D supporting NPPs in Canada, the primary focus of which is on the CANDU design.

### E.2 CANDU Owners' Group (COG) Research and Development Program

The COG R&D program addresses current and emerging operating issues to support the safe, reliable and economic operation of CANDU reactors in the areas of fuel channels; safety and licensing; health, safety and the environment; chemistry, materials and components; and the Industry Standard Toolset (software for design, safety analysis, and operational support).

The COG R&D program is co-funded by domestic CANDU licensees, Romania and AECL, with current funding of about \$40 million annually. COG R&D funding has shown an increased multi-year commitment. The current work in each area is listed below, with additional details provided for programs related to safety and licensing, and health, safety and the environment.

#### Fuel Channels

- hydride blister avoidance, deformation, deuterium ingress, flaw assessment, fitness-for-service guidelines, and assessment of pressure tube life

#### Safety and Licensing

- LBLOCA margins: licensing concerns (GAI closure) and restores operating and safety margins associated with predicted power pulses postulated for LBLOCA events (see LBLOCA is described later in this appendix)

- fission product source terms: licensing concerns (GAI closure) associated with discharges of hydrogen and steam for a postulated LOCA with postulated loss of emergency core coolant injection; provides improved quantification of fission product chemistry and aerosol behaviour in containment
- trip effectiveness criteria: provides improved accuracy and computational efficiency of thermohydraulic codes used in licensing analysis; improves the quantification of shutdown system operating and safety margins
- single channel severe overheating events: licensing issues (GAI closure) associated with postulated discharges of molten fuel into the moderator following a severe LOCA in a fuel channel, and the potential for further consequential damage to the reactor
- safety analysis technology: supports safety analysis software and common industry methodologies and analytical approaches
- fuel design and performance/fuel condition: addresses licensing concerns (GAI closure) by providing confirmation of acceptable fuel bundle performance under normal operating conditions; enhances techniques and tools to aid in locating defected fuel through development of code prediction capability of UO<sub>2</sub> oxidation under normal operating conditions
- plant aging and life extension: improves quantification of the impact of heat transport system and reactor core aging on plant operability
- severe accident research: addresses issues related to beyond design basis accidents or severe accidents

#### Health, Safety, and the Environment

- external dosimetry: develops and provides technically sound techniques and instruments for the assessment and control of external radiation doses received by nuclear workers and the public
- internal dosimetry: evaluates the radiological hazards associated with the uptake of radioactivity in the body, with a current focus on alpha activity from actinides encountered during refurbishment activities; also addresses the radiation health risk resulting from exposure to low doses and low dose rates and the biological effectiveness of various radiations
- radiation monitoring: develops and identifies new and improved radiation protection instruments, and evaluates them as they are introduced into the market
- environmental impact and biodiversity: establishes and verifies appropriate environmental risk assessment models and environmental monitoring programs and standards, to assess the impact of station operations on the environment including human and non-human biota
- occupational radiation protection: improves the radiation protection of station personnel by developing new equipment, strategies etc., in order to reduce the dose to personnel in keeping with ALARA and dose management considerations
- emissions management: characterizes station emissions, both radiological and non-radiological, and the implementation of appropriate monitoring systems to be able to quantify emission and identify actions that may be taken to reduce emissions

- spills management: develops appropriate spills risk assessment models, spills containment structures and processes and identification of best-in-business spills response practices
- waste management and pollution prevention: onsite radioactive (low and intermediate level) and conventional waste, the development of waste management parameters, identification of waste characteristics, and identification of best practices required to minimize waste production and promote efficient, cost effective handling to meet regulatory requirements
- environmental management systems: develops and guides implementation of managed system processes to reflect best-in-business environmental management systems, as required to maintain ISO 14001 certification and meet regulatory requirements

#### Chemistry, Materials, and Components

- chemistry
- reduction of radiation fields and dose
- non-destructive examination tools for steam generators and heat exchangers
- emergency core coolant strainer testing
- containment boundary degradation
- improved components, materials, maintenance and processes
- reactor vessel and piping material degradation
- steam generator and heat exchanger integrity and cleaning

#### Industry Standard Toolset

The Industry Standard Toolset program is a consolidation of the qualification, development and maintenance of different computer codes used for the design, safety analysis and operational support of CANDU reactors. This program is currently focused on 18 codes.

### **E.3 AECL Research and Development Program**

The principal objective of AECL's safety technology R&D is to understand the processes underlying the behaviour of CANDU reactors and other nuclear facilities under abnormal conditions, and to develop technology to mitigate the possible consequences of these conditions. The R&D programs also provide the technology base from which new products and services are developed to meet the customer and market needs. AECL is conducting significant R&D related to its development of the ACR-1000 and Enhanced CANDU 600 (EC6) reactor designs (see section D.1 of Chapter I for more information). Programs are in place to demonstrate and enhance passive safety, to understand the underlying phenomena and to develop associated analysis tools. These passive safety development activities are linked with the more general development undertaken by the Generation IV program (described below) and as part of future CANDU enhancements.

AECL safety technology R&D is currently conducted in the following programs:

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### Fuel Channels

- material science research required to understand the performance of the primary pressure boundary within a CANDU reactor, to understand and monitor potential failure mechanisms and to establish and maintain safe operation

### Reactor Chemistry and Systems

- research into nuclear steam plant and balance of plant chemistry, materials and the behaviour of components and cooling systems, required to understand and mitigate the effects of plant aging and to continue to ensure continued safe, reliable and cost-effective operation

### Safety Technology

- understand the basic phenomena and their interactions, required to assess and reduce the risks of an accident at a nuclear facility

### Physics and Fuel

- understand reactor and radiation physics and nuclear fuel technology, required to design, build and safely operate nuclear reactors

### Heavy Water and Hydrogen

- understand how to manage the heavy water in a CANDU reactor and exploit this technology (e.g., for the hydrogen economy)

### Environmental Emissions and Health Physics

- knowledge required to ensure the low levels of emissions from nuclear facilities meet environmental standards, to develop effective technologies for managing waste products from nuclear facilities, to address regulatory and public safety policy issues concerning nuclear technology, and to ensure that nuclear technology worker safety is exemplary

### Software Performance

- effective code management in compliance with quality assurance programs and requirements

### Information and Control

- knowledge to design, maintain, and enhance the plant control, plant display, plant monitoring, plant protection and other plant information systems of CANDU reactors

## **E.4 CNSC Research and Support Program**

The CNSC funds an external Research and Support Program to obtain knowledge and information needed to support CNSC staff in its regulatory mission. The program provides access to independent advice, expertise, experience and information through contracts, grants or contributions placed in the private sector and with other agencies and organizations in Canada and internationally.

The annual budget of the Research and Support Program is approximately \$3.2 million. On average, the program manages between 60 and 80 projects each year, with many projects running over more than one fiscal year.

The Research and Support Program issues grants and contributions to organizations such as the following:

- International Commission on Radiation Units (ICRU)
- Canadian Radiation Protection Association (CRPA)
- University Network of Excellence in Nuclear Engineering (UNENE)
- International Atomic Energy Agency (IAEA)
- UNSCEAR General Trust Fund, United Nations Environmental Program (UNEP)
- International Commission on Radiation Protection (ICRP)
- Canadian Standards Association (CSA)

Contracts issued under the Research and Support Program align with the CNSC's organization priority "Commitment to ongoing improvements" and address the following areas:

#### Evolution of Modern Benchmarks and Standards for Health, Safety and Environmental Protection

- Consolidating data and performance research to determine health, safety and environmental benchmarks ranging from release limits of substances to any emerging new concerns

#### New Builds

- Establishing a regulatory framework for new reactors
- Determining licensing requirements for new reactors and uranium mines

#### Operation of Current Facilities

- Identifying licensing issues and determining regulatory position given the age of the Canadian nuclear fleet

#### Future Technologies

- Enabling the CNSC to fully understand potential new and future technologies (small or new reactors, waste management, new isotope production facilities, aging facilities, international benchmarking, environmental standards) to ensure an up-to-date science base for use in regulatory functions

### **E.5 Generation IV International Forum**

The Generation IV International Forum began in 2001, when 10 countries initiated collaboration on the development of a fourth generation of nuclear energy systems. Euratom (representing the European Union) has also joined the forum, which includes Argentina, Brazil, Canada, France, Japan, Korea, South Africa, Switzerland, United Kingdom, and the United States.

Over 100 potential nuclear reactor concepts, or "systems", were reviewed by an international panel of experts. The panel selected the six reactor types that could best meet the Generation IV objectives of sustainability, economics, safety and reliability, and proliferation resistance and physical protection. Canada is participating in two systems that are the most natural evolution of current Canadian technology, the Supercritical-Water-Cooled Reactor and the Very-High-Temperature Reactor. The majority of the research being conducted is focused on the Supercritical-Water-Cooled Reactor, which is at the pre-conceptual stage of development.

Canada participates in the Generation IV International Forum through the Canadian National Program on Generation IV Energy Technologies. It brings together government, industry and universities from across the country through their participation in R&D focused on the multi-lateral development of advanced nuclear-based energy systems.

In May 2009, the Government of Canada announced an investment of 6 million dollars in grants over three years, to fund 23 Generation IV research projects at universities across Canada.

Through support for the new program, Canada is fulfilling part of its commitments as a charter member of the Generation IV International Forum, to develop the next generation of nuclear energy systems with a focus on improving safety, reducing waste, lowering costs and increasing resistance to proliferation.



## Appendix F

### Description and Results of CNSC's Assessment and Rating System for Nuclear Power Plants

The CNSC rating system used to assess the NPP licensees performance in the CNSC safety areas and programs, as described in previous Canadian reports, consisted of five categories:

- A Exceeds Requirements
- B Meets Requirements
- C Below Requirements
- D Significantly Below Requirements
- E Unacceptable

These rating categories were used in the *Annual CNSC Staff Report for 2007 on the Safety Performance of the Canadian Nuclear Power Industry*.

New rating categories were introduced for the *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plant for 2008* and were subsequently used in the 2009 annual report:

- FS Fully Satisfactory
- SA Satisfactory
- BE Below Expectations
- UA Unacceptable

The correspondence of the new categories to the old categories is shown in the following table.

Old Category	New Category
A	FS
B	SA
C	BE
D	UA
E	

The full definitions of the new categories, which are similar to the previous ones, are as follows.

#### **Fully Satisfactory (FS)**

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 (SA)**

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 (BE)**

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 (UA)**

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 methodology used by the CNSC to generate the ratings also improved in 2008. A risk-informed methodology was developed to systematically consider a wider range of input information for generating the ratings of safety areas and programs. The concept of an integrated plant rating — a weighted average of the safety area ratings for each NPP — was also introduced in 2008. The safety area weight factors were determined using an RIDM-based approach. The various requirements related to each of the CNSC safety areas were assessed. Likelihoods and consequences of adverse effects were estimated if each of those requirements were not enforced. The results were summed and normalized to represent the relative importance, or weight, of each safety area, with respect to overall NPP safety performance.

They were adjusted for 2009 based on new risk insights and a refinement of the method used to calculate them. Also, in 2009, the Safeguards safety area was excluded from the calculation, because it pertains to a very different part of the CNSC's mandate. The safety area weights used for 2008 and 2009 are provided in the following table.

Safety Area	Weights	
	2008	2009
Operating Performance	0.141	0.13
Performance Assurance	0.113	0.17
Design and Analysis	0.144	0.13
Equipment Fitness for Service	0.166	0.13
Emergency Preparedness	0.116	0.17
Environmental Protection	0.116	0.12
Radiation Protection	0.123	0.15
Safeguards	0.081	n/a

Table F.1 provides the definitions of the CNSC safety areas and programs for NPPs that were used during most of the reporting period. All the ratings discussed in this report are for this set of safety areas and programs. At the end of the reporting period, CNSC began transitioning to a revised set of safety and control areas that will apply to all facilities licensed by the CNSC. The revised set of CNSC safety and control areas correspond closely to the old set of safety areas and programs used for NPPs. The transition to the new set of CNSC safety and control areas will be completed during the next reporting period.

**Table F.1: CNSC Safety Areas, Programs and Review Factors used in Rating Canadian NPP Performance**

<b>Safety Area</b>	<b>Programs</b>	<b>Review Factors</b>
<b>1. Operating Performance</b>	1. Organization and Plant Management	<ul style="list-style-type: none"> <li>• global program integration</li> <li>• financial guarantees</li> <li>• review of station transients</li> <li>• overall plant status and material condition</li> <li>• reporting requirements (self-assessment and records)</li> <li>• public information program</li> </ul>
	2. Operations	<ul style="list-style-type: none"> <li>• field inspections</li> <li>• control room inspections</li> <li>• procedural adherence</li> <li>• communications</li> <li>• change control (approvals process, configuration management)</li> <li>• outage management</li> <li>• plant walk-downs (fire protection, environmental qualification, emergency preparedness, configuration management, emergency core cooling flow path, seismic etc.)</li> <li>• operator certifications (internal certification process, records)</li> </ul>
	3. Occupational Health and Safety (Non-radiological)	<ul style="list-style-type: none"> <li>• industrial health and safety standards</li> <li>• hazardous materials management</li> <li>• worker health and safety committees</li> <li>• work planning, work practices and protection, reporting and records other government programs or requirements</li> </ul>
<b>2. Performance Assurance</b>	1. Quality Management	<ul style="list-style-type: none"> <li>• program definition (quality management manual, policies, procedures)</li> <li>• identification and resolution of problems</li> <li>• management self-assessments</li> <li>• work planning, change control, documentation control, control of items processes and practices, records</li> <li>• use of operating experience (OPEX)</li> <li>• organization design, departmental roles and responsibilities, communication, accountability</li> </ul>
	2. Human Factors	<ul style="list-style-type: none"> <li>• human system interface</li> <li>• fitness for duty</li> <li>• work environment</li> <li>• staffing (process, levels)</li> <li>• procedures and job aids, maintenance of procedures</li> <li>• organizational factors including safety culture</li> </ul>
	3. Training	<ul style="list-style-type: none"> <li>• personnel qualifications, capabilities</li> <li>• training processes and procedures</li> <li>• certified staff training (examination/standards/procedures)</li> <li>• non-certified staff training</li> <li>• facilities and support services (simulator/aids/classroom)</li> </ul>
<b>3. Design and</b>	1. Safety Analysis	<ul style="list-style-type: none"> <li>• safety analysis report update</li> </ul>

Safety Area	Programs	Review Factors
<b>Analysis</b>		<ul style="list-style-type: none"> <li>licensing basis (assumptions)</li> <li>safe operating envelope (operating policies and principles)</li> <li>methodology and model verification and validation</li> <li>aging (impact on safety analysis)</li> </ul>
	2. Safety Issues	<ul style="list-style-type: none"> <li>research and incorporation of new knowledge</li> <li>action item placement and management (generic, site specific)</li> <li>hazard analyses (internal, external, fire hazard assessment)</li> <li>accident mitigation and management</li> </ul>
	3. Design	<ul style="list-style-type: none"> <li>description of plant design (documentation of design basis, system classification, configuration management)</li> <li>fire protection</li> <li>design change projects (safety enhancements, links to events, corrective actions, OPEX, human factors)</li> </ul>
<b>4. Equipment Fitness for Service</b>	1. Maintenance	<ul style="list-style-type: none"> <li>work control and conduct of maintenance (permits and procedures)</li> <li>procedural adherence (procedures and job aids)</li> <li>planning (maintenance activities and backlog reduction, corrective maintenance, preventive maintenance)</li> <li>surveillance and inspection</li> <li>plant life management (aging/obsolescence)</li> <li>facilities, equipment and materials</li> <li>stores and warehouses</li> <li>configuration management</li> </ul>
	2. Structural Integrity	<ul style="list-style-type: none"> <li>pressure retaining components</li> <li>in service inspection</li> <li>fitness for service programs</li> </ul>
	3. Reliability	<ul style="list-style-type: none"> <li>probabilistic safety assessment, models and methodology</li> <li>system unavailability performance</li> </ul>
	4. Equipment Qualification	<ul style="list-style-type: none"> <li>environmental</li> <li>seismic</li> <li>fire protection</li> <li>quality level</li> <li>electronic/magnetic interference</li> <li>chemistry control</li> </ul>
<b>5. Emergency Preparedness</b>	1. Emergency Preparedness	<ul style="list-style-type: none"> <li>emergency response</li> <li>consolidated emergency plan (fire response and mitigation considerations, security, other events)</li> <li>emergency response training exercises</li> <li>emergency response facilities and procedures</li> </ul>

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<b>Safety Area</b>	<b>Programs</b>	<b>Review Topics</b>
<b>6. Environmental Protection</b>	1. Environmental management systems	<ul style="list-style-type: none"><li>• environmental protection systems</li><li>• emissions reduction</li><li>• pollution prevention</li></ul>
<b>7. Radiation Protection</b>	1. Personnel exposure	<ul style="list-style-type: none"><li>• radiation exposure control (ALARA, dose control during outages)</li><li>• action levels</li><li>• contamination control</li></ul>

Note:

Two additional CNSC safety areas, “Site Security” and Safeguards”, have been omitted from the table.

Table F.2: Performance Ratings of Safety Areas for NPPs for the years 2007, 2008 and 2009

	Bruce A			Bruce B			Darlington			Pickering A			Pickering B			Gentilly-2			Point Lepreau		
	'07	'08	'09	'07	'08	'09	'07	'08	'09	'07	'08	'09	'07	'08	'09	'07	'08	'09	'07	'08	'09
<b>Operating Performance</b>	B	SA	FS	B	SA	FS	B	FS	FS	C	SA	SA	B	SA	SA	B	SA	SA	B	FS	SA
<b>Performance Assurance</b>	B	SA	SA	B	SA	SA	B	SA	SA	C	SA	SA	B	SA	SA	B	SA	SA	B	SA	SA
<b>Design &amp; Analysis</b>	B	SA	SA	B	SA	SA	B	SA	SA	B	SA	SA	B	SA	SA	B	SA	SA	B	SA	SA
<b>Equipment Fitness for Service</b>	B	SA	SA	B	SA	SA	B	SA	SA	B	SA	SA	B	SA	SA	B	SA	SA	B	SA	*
<b>Emergency Preparedness</b>	A	FS	FS	A	FS	FS	A	FS	FS	A	SA	SA	A	SA	SA	B	FS	FS	B	FS	*
<b>Environmental Protection</b>	B	SA	SA	B	SA	SA	B	SA	SA	B	BE	SA	B	BE	SA	B	SA	SA	B	SA	SA
<b>Radiation Protection</b>	B	SA	SA	B	SA	SA	A	FS	SA	B	SA	SA	B	SA	SA	B	SA	SA	B	SA	SA
<b>Integrated Plant Rating</b>	n/a	FS	FS	n/a	FS	FS	n/a	FS	FS	n/a	SA	SA	n/a	SA	SA	n/a	SA	SA	n/a	SA	SA

**Legend:**Categories for 2007 Ratings

A = Exceeds requirements B = Meets requirements C = Below requirements

Categories for 2008, 2009 Ratings

FS = Fully Satisfactory SA = Satisfactory BE = Below Expectations

**Notes:**

\* The performance of Equipment Fitness for Service and Emergency Preparedness were not rated for Point Lepreau in 2009, because the NPP was being refurbished.

The grades for the CNSC safety areas “Site Security” and Safeguards” have been omitted from the table.

## Appendix G

### CANDU Safety Issues

#### G.1 Process to Identify and Risk-Rank CANDU Safety Issues

During the reporting period, the CNSC and the industry assessed the current status of outstanding design and safety analysis issues for Canadian CANDU reactors, and developed a risk-informed path forward to address concerns on nuclear safety in relation to life extension projects and operating reactors. As a result of this review, the CNSC issued a report entitled *Application of the CNSC Risk-Informed Decision Making Process to Category 3 CANDU Safety Issues – Development of Risk-Informed Regulatory Position for CANDU Safety Issues*.

The initial list of safety issues was developed using the IAEA document *Generic Safety Issues for Nuclear Power Plants with Pressurized Heavy Water Reactors and Measures for their Resolution* (TECDOC-1554). Additional issues were identified through regulatory oversight of currently operating reactors, results of life extension assessments and safety issues identified in pre-licensing reviews of new CANDU designs. The issues covered by generic action items (GAI) were included. GAIs are regulatory tools that have been used to a) define the scope of certain safety issues that are common to more than one NPP and b) track the progress of their resolution. An update on the status of the GAIs is provided at the end of this Appendix.

The safety issues 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 are issues that have been satisfactorily addressed in Canada.
- Category 2 are 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 need to be confirmed.

The existence of Category 3 issues should not be viewed as questioning the safety of existing NPPs, which have attained a very high operational safety record in Canada, but rather as the clear identification areas where uncertainty in knowledge exists, where the safety assessment has been based on conservative assumptions, and where regulatory decisions are needed, or will need to be confirmed.

A total of 73 safety issues pertaining to plant design and analysis were identified during the first part of the project, of which 20 were considered potentially risk-significant (Category 3). Subsequently, a Risk Informed Decision Making process (RIDM; described in subsection 8.1 d) was applied to the Category 3 issues, to identify, estimate and evaluate the risks associated with each of them, and to recommend measures to control these risks. In accordance with defense-in-depth principles, the risk assessment covered all possible combinations of events that could potentially lead to fuel damage, adverse effects on the workers, the public or the environment, or any combination thereof. The application of the RIDM process by a joint CNSC/industry working group developed a consensus on the:

- definition of the generic safety issues applicable to the nuclear power plants currently operating in Canada

- risk significance levels of the issues relative to the various safety areas
- risk control measures that are appropriate to address the issues, including high-level plans to implement these measures

Risk control measures are generally aimed at improving the understanding of the safety issue, and to address margins and uncertainties associated with them. None of the scenarios studied yielded a risk significance level that required immediate corrective action.

As per the RIDM process, an updated risk evaluation and assessment of the 20 Category 3 issues resulted in the re-categorization of four of these issues to lower categories. The remaining 16 Category 3 issues include five associated with large-break loss of coolant accidents (LBLOCA), and eleven other safety issues that are not associated with LBLOCA.

## **G.2 CANDU Safety Issues Associated with LBLOCA**

Positive coolant void reactivity feedback is an intrinsic design feature of CANDU reactors. It stems mainly from the separation of the coolant from the moderator and utilization of un-enriched uranium-oxide as fuel to power these reactors. Current CANDU reactor designs include specific provisions to address this intrinsic feature of the design, by employing multiple protective measures to provide defence-in-depth. The most important protective provision is the presence of two reliable, diverse, independent, fully effective, fast-acting automated shutdown systems that are independent of the reactor control system. The two shutdown systems are complemented by robust ECC and containment systems that together ensure that any power surge associated with positive coolant void reactivity is controlled, the core is adequately cooled and possible radioactive releases are contained within regulatory limits following an accident initiation.

LBLOCA is a design basis accident (DBA) that is postulated to occur as a result of a sudden failure of a large diameter pipe in the heat transport system. LBLOCA is the DBA used to set the requirements for the speed of the shutdown systems and the requirements for the ECC. LBLOCA involves simultaneous rapid degradation of cooling capability and the fastest possible rate of positive reactivity insertion, due to rapid core voiding. The resulting power pulse is terminated by activation of one of the two shutdown systems within less than two seconds after accident initiation.

Furthermore, unlikely combinations of events, such as LBLOCA combined with unavailability of ECC, have been considered in the design of the CANDU reactors. Even though these event combinations are considered by other jurisdictions to belong to the beyond design basis accident (BDBA) category, they are currently treated as DBA in the Canadian regulatory framework.

The impact of a power pulse following a LBLOCA is explicitly analysed in the safety analysis reports. The current safety analysis methodology used for LBLOCA scenarios incorporates numerous conservative assumptions with regard to the state of reactor, both before and after the accident initiation. As documented in these reports, the design meets the current acceptance criteria and regulatory dose limits. However, LBLOCA safety margins have eroded over the past decade, due to experimental findings that concluded that the actual value of full-core void reactivity was higher than what was assumed in the safety analysis reports.



To address the reductions in the LBLOCA safety margins, there are currently five Category 3 CANDU safety issues that are directly related to LBLOCA. They are:

- analysis for void reactivity
- channel voiding during LBLOCA
- fuel behaviour in high temperature transients
- fuel behaviour in power pulse transients
- moderator sub-cooling availability

In 2008, a joint industry/CNSC working group was established to identify possible options for a resolution path to address the issues associated with LBLOCA safety margin in existing CANDU reactors. Two resolution strategies were proposed by the working group:

- the composite analytical approach (industry's primary choice)
- the design change strategy (back-up option)

#### Composite Analytical Approach

The objective of the composite analytical approach is to demonstrate the following:

- The probability of having a break in a large CANDU primary heat transport system pipe is low.
- The probability of a large, instantaneous break in that pipe is low.
- The LBLOCA safety margins for most probable operating states are large.

Consequently, the composite analytical approach focuses on:

- establishing large pipe break frequencies that would result in possible re-classification of LBLOCA pipe break scenarios into the DBA and BDBA categories
- developing and validating a more realistic crack opening model for progression of a break in a large pipe (instead of the current assumption of a double-ended instantaneous guillotine break)
- further development of a best estimate plus uncertainty (BEAU) methodology to augment the deterministic safety analysis of LBLOCA

The BEAU methodology assumes more realistic initial and boundary conditions with all uncertainties (those associated with assumptions, models, and computer codes) defined to a high level of confidence.

#### Design Change Strategy

The objective of the design change strategy is to introduce changes in the design and operation of the reactors, in order to restore the degraded safety margins if the composite analytical approach is not accepted by CNSC. The degraded safety margins could either be restored via improving the effectiveness of the shutdown systems, or via other means of reducing the size of the power pulse following LBLOCA. Specifically, the design change strategy focuses on feasibility of:

- changes to operational practices
- modifications to shutdown systems
- implementation of low void reactivity (LVR) fuel

### Resolution of CANDU Safety Issues Related to LBLOCA

Assessments of the merits of the composite analytical approach and the design change strategy indicated that they are comparable in addressing the LBLOCA-related CANDU safety issues. The CNSC accepted the industry's proposal to primarily pursue the composite analytical approach to address the issues.

An industry steering committee was established through COG, under the direction of the Canadian Nuclear Utility Executive Forum, to coordinate industry's implementation of the composite analytical approach. The industry documented the justification of the selected option, including the technical rationale, implementation timeline, and development and implementation costs. The industry established two working groups to a) resolve analysis issues and b) assess failure probability and break-opening characteristics related to LBLOCA. The resolution of the LBLOCA-related, Category 3 CANDU safety issues is expected by the end of 2013.

To optimize the probability of success of the approach, the industry is preparing a detailed program and a schedule for development and implementation of the composite analytical approach that defines the scope, tasks, and success criteria for individual elements. Terms of reference will establish clear accountabilities for the industry participants and the CNSC. The industry also implemented a monitoring process to:

- demonstrate that the level of confidence in the successful outcome of the composite analytical approach increase with time and
- verify that the proposed approach is effective in reducing the negative impact on safety of the Category 3 issues related to LBLOCA.

The industry has issued a state-of-the-art report on fundamental aspects of CANDU fuel behaviour at high temperature and is planning high-temperature fuel bundle deformation tests. The analysis working group has also identified the following fundamental activities that will be pursued in conjunction with the composite analytical approach (although they complement both resolution strategies):

- re-evaluation of LBLOCA acceptance criteria (safety margin issue)
- re-evaluation of the uncertainty associated with the coolant void reactivity

The industry steering committee is also responsible for developing high-level plans for the design change strategy in the event that the composite analytical approach is unsuccessful. It should be noted that even though the design change strategy is designated as a backup option to the composite analytical approach, the Canadian nuclear industry, over the past several years, has performed (and is still performing) a number of feasibility studies for implementation of design changes.

Bruce Power's demonstration irradiation of LVR fuel (described in the fourth Canadian report) was successfully completed during the reporting period. Plans for the full-core implementation of LVR fuel have been suspended while Bruce Power focuses effort on the industry work to implement the composite analytical approach and also on improvements to the shutdown systems to enhance LBLOCA safety margins.

Many modifications to operational practices have already been introduced by the licensees to further mitigate the consequences of LBLOCA. A significant operational and engineering change, described in the fourth Canadian report, is Bruce Power's conversion from on-line loading of fuel bundles against the normal direction of coolant flow to fuelling with the flow. This modification reduces the amount of "fresh" fuel (and hence reactivity) that could be inserted into the core due to fuel string relocation from flow reversal following a LBLOCA, thus improving LBLOCA safety margins.

The cores of Bruce A Units 3 and 4 and Bruce B Units 6 and 7 had already been converted to fuelling with the flow. During this reporting period, the conversion of Unit 5 and 8 was completed. With the increased safety margins for LBLOCA, the Bruce B operating licence was amended to allow Units 5, 6, 7 and 8 to increase to 93% full power.

Besides the initiatives described above, the industry is also evaluating global progress in risk-informed methods, including break preclusion and risk-informed inspection, to assess how these methods can be applied to LBLOCA. Application of risk-informed methods should provide increased assurance of event prevention, which is the first line of defence. Use of a risk-informed approach may also provide improved insights from an overall risk perspective, to ensure appropriate allocation of resources to this issue.

### **G.3 Non-LBLOCA CANDU Safety Issues**

For non-LBLOCA Category 3 issues, the results of applying the RIDM process indicate that most of the outstanding safety issues will be addressed by further work in the following areas:

- validation of data, models and codes used in accident analysis
- acquisition of additional experimental data on fuel behaviour under accident conditions
- management of aging of SSCs, and assessment of the impact of aging on the plant response to accidents
- implementation of design improvements to be confirmed by the above activities.

The RIDM process identified high-level plans for addressing the non-LBLOCA Category 3 issues. One risk control measure has been identified for each issue, and there is a consensus between the CNSC staff and the industry on the high-level plans to implement them.

An example of a non-LBLOCA Category 3 issue is the impact of plant aging on safety analysis. Bruce Power and OPG have introduced a new neutron over-power analysis methodology to assess one of the events most impacted by aging — the slow loss of regulation event. An independent technical panel, jointly sponsored by the CNSC and industry, reviewed the methodology during the reporting period. The panel concluded that the overall methodology had a sound technical basis, but recommended additional justification, supplemental analysis and revisions prior to final acceptance in the regulatory process. CNSC staff agreed with the conclusions of the panel, and advised the industry that further development work is required on this methodology before its full utilization for licensing applications.

In the next reporting period, the other working groups will describe risk control measures, and provide a timetable of implementation, for the other Category 3 issues. Once accepted by the CNSC, it will provide the framework for regulatory oversight of their resolution.

#### G.4 Status of Generic Action Items

Most of the safety issues covered by the GAIs (defined above, under subsection G.1) are now covered by the CANDU safety issues, and those not covered are near resolution. Table G.1 summarizes the current status of the GAIs that were open during the reporting period.

**Table G.1: Status of GAIs as of March 31, 2010**

<b>GAI</b>	<b>Title</b>	<b>Brief Description</b>	<b>Status as of March 2010</b>	<b>Planned Closure Date</b>
88G02	Hydrogen behaviour in CANDU nuclear generating stations	Loss of coolant accidents can lead to substantial hydrogen releases into containment. Containment integrity must be assured.	Closed	N/A
94G02	Impact of fuel bundle condition on reactor safety	The effects of bundle degradation on reactor safety are not fully known, partially because of the limitations of safety analysis methods. It is necessary to conduct an integrated evaluation of information obtained from inspections and examinations, research and safety analyses.	Closed for all NPPs except Gentilly-2, where work is in progress	2010
95G01	Molten fuel-moderator interaction	Severe flow blockage in a fuel channel, or flow stagnation, could potentially lead to fuel and ejection of molten fuel into the moderator. This scenario and its potential consequences need to be well understood.	Closed	N/A
95G02	Pressure tube failure with consequential loss of moderator	For dual failures involving pressure tube rupture plus loss of emergency core coolant, the moderator may not be available to provide cooling for the fuel channels, due to the possibility of end fitting ejection leading to moderator drainage. Severe accident frequency following this scenario needs to be determined.	Closed for all NPPs except Gentilly-2, where work is in progress; included in CANDU safety issues	2010
95G04	Positive void reactivity uncertainty - treatment in large LOCA analysis	Accuracy of void reactivity calculations is a significant safety issue in the analysis of design basis accidents involving channel voiding especially for large LOCAs. Uncertainties and safety margin adequacy are the main questions.	Included in CANDU safety issues; Closure will depend on recommendations by joint industry/CNSC RIDM team (linked to GAI 99G02)	2013
95G05	Moderator temperature predictions	In some large LOCA scenarios, channels may fail if the moderator temperature is too high to prevent calandria tube external dryout. Computer codes predicting moderator temperatures need to be adequately validated.	Closed for all site except Bruce A and Pickering A, for which additional experiments were requested;	2010

<b>GAI</b>	<b>Title</b>	<b>Brief Description</b>	<b>Status as of March 2010</b>	<b>Planned Closure Date</b>
			included in CANDU safety issues	
99G01	Quality Assurance of Safety Analysis	Inadequate quality assurance of safety analysis was resulting in a reduction in overall confidence in the results.	Closed	N/A
99G02	Replacement of reactor physics computer codes used in safety analyses of CANDU reactors	Shortcomings need to be rectified, with respect to inaccurate computer code predictions of key parameters for accident conditions, lack of proper validation, and a lag of licensees' methods and codes behind the state of knowledge in this area.	Included in CANDU safety issues; closure will depend on recommendations by joint industry/CNSC RIDM team (linked to GAI 95G04)	2013
00G01	Channel voiding during a LOCA	At issue is the adequate validation of computer codes used for the prediction of overpower transients for CANDU reactors with a positive coolant void reactivity coefficient.	Included in CANDU safety issues; work in progress	2010
01G01	Fuel management and surveillance software upgrade	Compliance with reactor physics safety limits defining the safe operating envelope, such as channel and bundle power limits, has enhanced the need for an improved analytical model, validated over a broader range of applications and conditions, plus better-defined compliance allowances and more consistent procedures.	Closure under CNSC review	2010
06G01	Emergency core coolant strainer deposits	A postulated LOCA would dislodge significant quantities of insulation material, which could potentially lead to partial blockage of the strainers, thereby impairing emergency core coolant recirculation. Station-specific studies need to be undertaken, followed by appropriate compensatory measures.	Closed	N/A



## Appendix H

### CNSC Risk-Informed Decision Making Process

To support a common, reasonable, and consultative decision making process, CNSC management adopted the CSA document *Risk Management: Guideline for Decision Makers* (CAN/CSA Q850) as the basis for its risk management approach and specifically for developing its risk-informed decision making (RIDM) process. Endorsed by the Standards Council of Canada, Q850 is a tool to aid decision-makers in identifying, analyzing, evaluating and controlling risks, including risks to safety and health. This tool also helps with priority setting, which is an inevitable part of the management of risk in the context of limited available resources. Furthermore, Q850 reinforces the importance of communications for effective risk management by involving and consulting people, especially those who would normally be directly affected by a given decision, and documenting each step.

Overall, this tool:

- ensures that all aspects of the risk problem are identified and considered when making decisions
- ensures that legitimate interests of affected stakeholders are considered
- provides decision makers with a solid justification in support of decisions
- enables decision-makers to make easier-to-explain decisions
- provides a standardized set of terminology used to describe risk issues
- contributing to better communication about risk issues
- provides an explicit treatment of uncertainty

RIDM, however, does not guarantee a single, correct course of action, and does not direct the individual or the organization to pre-determined courses of action.

The RIDM process integrates a spectrum of inputs to result in safe, sound and optimal decision. These inputs include:

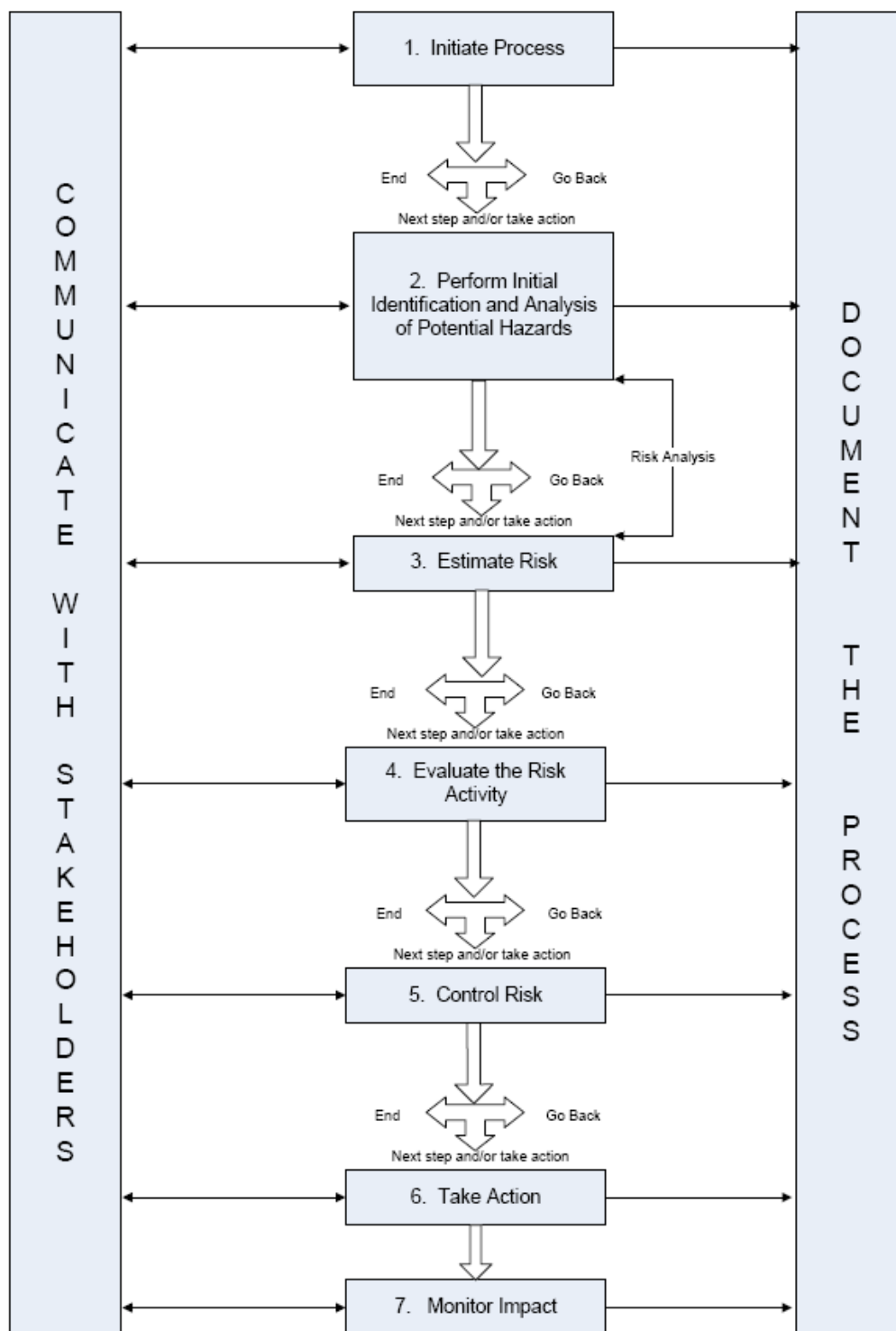
- regulatory requirements, standards and codes
- deterministic safety analyses
- probabilistic safety analyses
- risk impact`
- operating experience
- other considerations (e.g. cost-benefit, socioeconomic implications, legal aspects)

The RIDM process is depicted in Figure H.1.

A guidance document on the application of RIDM to regulatory decision making situations in licensing, compliance and planning is available (in English only) from the CNSC upon request.

Since its introduction, the RIDM process has been successfully used in several power reactor licensing and compliance applications. An example is provided below (see also subsection 14 (i) for the application of RIDM to CANDU safety issues) and Appendix F for application of RIDM to the CNSC safety area rating system for NPPs.

Figure H.1: RIDM process





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### Example of the Application of RIDM: Technical Assessment of Off-Normal Conditions

In spring 2008, Unit 7 of Pickering B was placed in a moderator-drained guaranteed shutdown state (GSS), following an unexplained decrease in gadolinium concentration that occurred while the unit was in over-poisoned GSS. The licensee's investigation into the event found that elevated CO<sub>2</sub> levels from a small annulus gas leak had led to the formation of insoluble gadolinium oxalate.

To remove the gadolinium that was not removed during the transition to the moderator drained GSS, the moderator system needed to be refilled so that it could be purified. A GSS was required that did not rely on moderator poison.

OPG proposed a rod-based GSS, which relies on the shut-off rods, control absorbers and adjuster rods being guaranteed in-core to ensure sub-criticality. The rod-based GSS was an un-analysed GSS, and deviated from the operating policies and principles (OP&P). Consequently, CNSC approval was required before the proposal could be implemented.

Through the application of RIDM, CNSC staff determined that with operational, physical and administrative barriers in place, allowing OPG to deviate from OP&P would not pose any unreasonable risk to the health and safety of persons, protection of the environment, maintenance of national security, and measures required to implement Canada's international obligations. Furthermore, the staff concluded that although alternatives to the use of RBGSS for recovery of Unit 7 (e.g. defuelling the reactor and using light water to flush the moderator) could reduce the risk of inadvertent criticality, this option would introduce additional dose to workers and have greater impact on the environment.



## **ANNEXES**



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## Annex 7.2 (i) a CNSC Regulation Making Process

When making or amending regulations, the CNSC must abide by the Government of Canada's regulatory policy *Cabinet Directive on Streamlining Regulations*, which came into effect April 1, 2007. Under this directive, the CNSC requests the Secretariat of the Federal Treasury Board to assess regulatory proposals at an early stage, by submitting a triage statement. The following factors are considered in this statement:

- potential impact of the regulation on health and safety, security, the environment, and the social and economic well-being of Canadians
- cost or savings to government, business, or Canadians and the potential impact on the Canadian economy and its international competitiveness
- potential impact on other federal departments or agencies, other governments in Canada, or on Canada's foreign affairs
- degree of interest, contention, and support among affected parties and Canadians

Once the triage statement is approved by the Treasury Board Secretariat, the CNSC, with assistance from the Department of Justice, proceeds with drafting the regulations and consulting stakeholders. The CNSC 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 their different levels of interest, points of view, and expectations concerning the nature and content of a proposed regulatory regime. Internally, CNSC staff communications inform interested colleagues of the proposed consultative process and the proposed regulations. Externally, the CNSC coordinates regulatory consultations with other departments and agencies.

The draft regulations undergo a series of internal approvals before being presented to the minister of Natural Resources Canada for approval for pre-publication in *Canada Gazette Part I*. Pre-publication in the *Canada Gazette* is a requirement of the *Statutory Instruments Act* and Treasury Board policies, and is intended to ensure that all Canadians have the opportunity to comment on the regulations being made. The comment period varies between 30 to 75 days. Comments received during the pre-publication are posted on CNSC's Web site for interested parties, to provide feedback.

Following the pre-publication comment period, the draft regulations are amended, if necessary, to take into account the comments received. Once the final draft regulations are completed, they must again be circulated for internal approvals before being presented to the Commission Tribunal. A regulation is "made" when it is officially established by the regulation-making authority. Under section 44 of the NSCA, the Commission Tribunal may make regulations with the approval of the governor in council (federal cabinet). Governor in council approval is granted following a recommendation for approval from the minister of Natural Resources Canada. Once approved, the new or amended regulations are published in the *Canada Gazette Part II*.

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## Annex 7.2 (i) b Regulatory Framework Documents

The information in this annex reflects the status of the CNSC regulatory document program at the end of the reporting period.

The CNSC's revised regulatory framework contains the following categories of documents:

- Regulatory Documents (RD) provide greater detail than regulations as to what licensees and applicants must achieve in order to meet the regulatory requirements of the CNSC.
- Guidance Documents (GD) provide practical guidance to licensees and applicants on how to meet the regulatory requirements of the CNSC.
- INFO-Documents (INFO) are plain-language publications that describe nuclear-related issues and regulatory requirements and processes, for the general public and other stakeholders. INFO-Documents also provide support and further information on other elements of the regulatory framework.

The previous naming conventions are described in the footnote to Table 7.2 (i) b.1 below.

The regulatory document process includes two sub-processes: the document identification process and the document development process. The document identification process begins with a call for regulatory document proposals, and ends with a group of approved regulatory document proposals. The document development process involves the development of the regulatory document, from work plan to published regulatory document. External stakeholders have the opportunity to comment on the list of proposed documents during the document identification process, and on the content of the individual documents during the development process.

Additional information on the CNSC's regulatory documents program is available on the CNSC Web site at [nuclearsafety.gc.ca](http://nuclearsafety.gc.ca)

The tables below list some key documents that are relevant to NPPs. CNSC documents are listed in Table 7.2 (i) b.1; they are also available on the CNSC Web site at [nuclearsafety.gc.ca](http://nuclearsafety.gc.ca). CSA documents are listed in Table 7.2 (i) b.2.

**Table 7.2 (i) b.1: Regulatory Framework Documents (CNSC and AECB) Related to NPPs**

<b>Doc #<sup>3</sup></b>	<b>Document Title</b>
RD-363	Nuclear Security Officer Medical, Physical, and Psychological Fitness (2008)
RD-353	Testing the Implementation of Emergency Measures (2008)
RD-346	Site Evaluation for New Nuclear Power Plants (2008)
RD-337	Design of New Nuclear Power Plants (2008)
RD-360	Life Extension of Nuclear Power Plants (2008)
RD-310	Safety Analysis for Nuclear Power Plants (2008)
RD-204	Certification of Persons Working at Nuclear Power Plants (2008)
P-119	Policy on Human Factors (2000)
P-211	Compliance (2001)
P-223	Protection of the Environment (2001)
P-290	Managing Radioactive Waste (2004)
P-299	Regulatory Fundamentals (2005)
P-325	Nuclear Emergency Management (2006)
R-7	Requirements for Containment Systems for CANDU Nuclear Power Stations (1991)
R-8	Requirements for Shutdown Systems for CANDU Nuclear Power Stations (1991)
R-9	Requirements for Emergency Core Cooling Systems for CANDU Power Plants (1991)
S-98 rev.1	Reliability Programs for Nuclear Power Plants (2005)
S-99	Reporting Requirements for Operating Nuclear Power Plants (2003)
S-210	Maintenance Programs for Nuclear Power Plants (2007)
S-294	Probabilistic Safety Assessment (PSA) for Nuclear Power Plants (2005)
S-296	Environmental Protection Policies, Programs and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills (2006)
G-129 rev.1	Keeping Radiation Exposures and Doses “As Low as Reasonably Achievable (ALARA)” (2004)
G-144	Trip Parameter Acceptance Criteria for the Safety Analysis of CANDU Nuclear Power Plants (2006)
G-206	Financial Guarantees for the Decommissioning of Licensed Activities (2000)
G-219	Decommissioning Planning for Licensed Activities (2000)
G-225	Emergency Planning at Class I Nuclear Facilities and Uranium Mines and Mills (2001)
G-228	Developing and Using Action Levels (2001)
G-276	Human Factors Engineering Program Plans (2003)
G-278	Human Factors Verification and Validation Plans (2003)
G-306	Severe Accident Management Programs for Nuclear Reactors (2006)
G-323	Ensuring the Presence of Sufficient Qualified Staff at Class I Facilities – Minimum Staff Complement (2007)
C-006	Requirements for the Safety Analysis of CANDU Nuclear Power Plants (draft)

<sup>3</sup> The naming convention for regulatory documents has evolved over time. AECB (predecessor to the CNSC) regulatory documents were typically denoted by the prefix “R”, indicating “regulatory”. Draft regulatory documents were designated “C” for “consultative”. CNSC regulatory policies, standards, guides and notices were initially denoted by a “P”, “S”, “G” or “N” respectively. In 2007, all regulatory documents were given the prefix “RD”. The current naming convention, established in December 2009, uses the designation “RD” for documents containing requirements. Documents containing guidance use the designation “GD”.

**Table 7.2 (i) b.2: CSA Documents Related to NPPs**

<b>Doc #</b>	<b>Document Title</b>
N285.0	General requirements for pressure-retaining systems and components in CANDU nuclear power plants (2008)
N285.4	Periodic inspection of CANDU nuclear power plant components (2009)
N285.5	Periodic inspection of CANDU nuclear power plant containment components (2008)
N285.6	Material standards for reactor components for CANDU nuclear power plants (2008)
N286.0	Overall Quality Assurance Program Requirements for Nuclear Power Plants (1992 reaffirmed 1998)
N286	Management System Requirements for Nuclear Power Plants (2005)
N286.7	Quality Assurance Of Analytical, Scientific And Design Computer Programs For Nuclear Power Plants (1999 reaffirmed 2007)
N286.7.1	Guideline for the application of N286.7-99, Quality assurance of analytical, scientific, and design computer programs for nuclear power plants (2009)
N287.2	Material requirements for concrete containment structures for CANDU nuclear power plants (2008)
N287.4	Construction, fabrication, and installation requirements for concrete containment structures for CANDU nuclear power plants (2009)
N287.7	In-service examination and testing requirements for concrete containment structures for CANDU nuclear power plants (2008)
N288.1	Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities (reaffirmed 2008)
N288.4-	Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills (2010)
N289.1	General requirements for seismic design and qualification of CANDU nuclear power plants (2008)
N289.2	Ground motion determination for seismic qualification of nuclear power plants (2010)
N289.3	Design procedures for seismic qualification of nuclear power plants (2010)
N290.6	Requirements for monitoring and display of nuclear power plant safety functions in the event of an accident (2009)
N290.13	Environmental qualification of equipment for CANDU nuclear power plants (2005 and Update 1 (2009))
N290.14	Qualification of Pre-Developed Software for Use in Safety-Related Instrumentation and Control Applications in Nuclear Power Plants (2007)
N291	Requirements for Safety-Related Structures for CANDU Nuclear Power Plants (2008)
N292.2	Interim Dry Storage of Irradiated Fuel (2007)
N292.3	Management of Low- and Intermediate-Level Radioactive Waste (2008)
N293	Fire Protection For CANDU Nuclear Power Plants (2007, Consolidated)
N294	Decommissioning of facilities containing nuclear substances (2009)

#### Use of IAEA Documents in CNSC Regulatory Documents

IAEA standards continue to serve as references and benchmarks for the Canadian nuclear safety documents, as they have for many years. The following table identifies some published and draft CNSC regulatory documents that were developed using IAEA standards.



**Table 7.2 (i) b.3: CNSC Documents for NPPs that were developed using IAEA standards**

<b>CNSC Document</b>	<b>Associated IAEA Standard</b>
RD-363, <i>Nuclear Security Officer Medical, Physical, and Psychological Fitness</i>	1. Safety Standards Series, NS-G-2.8.
RD-353, <i>Testing the Implementation of Emergency Measures</i>	1. Safety Series No. 73 2. Safety Standards Series no. GS-R-2
RD-346, <i>Site Evaluation for New Nuclear Power Plants</i>	1. Safety Standards Series No. NS-G-3.2 2. Safety Standards Series No. NS-G-3.3 3. Safety Standards Series No. NS-G-1.5 4. Safety Standards Series No. NS-G-3.1 5. Safety Standards Series No. NS-G-3.5 6. Safety Standards, Series No. NS-G-3.6, 7. Safety Standards Series No. NS-G-3.4 8. Safety Series No. 50-C/SG-Q 9. Safety Standards Series No. NS-R-3 10. Safety Series No. 110
RD-337, <i>Design of New Nuclear Power Plants</i>	1. Safety Standard Series NS-R-1
RD-360, <i>Life Extension of Nuclear Power Plants</i>	1. Safety Standards Series No. NS-G-2.10
RD-204, <i>Certification of Persons Working at Nuclear Power Plants</i>	1. Safety Guide No. NS-G-2.4 2. Safety Guide No. NS-G-2.8
S-294, <i>Probabilistic Safety Assessments (PSA) for Nuclear Power Plants</i>	1. Safety Series No. 50-P-4 <i>Procedures for Conducting Probabilistic Safety Assessments of Nuclear Power Plants (Level 1)</i> 2. Safety Series No. 50-P-8 <i>Procedures for Conducting Probabilistic Safety Assessments of Nuclear Power Plants (Level 2), Accident Progression, Containment Analysis and Estimation of Accident Source Terms</i>
S-210, <i>Maintenance Programs for Nuclear Power Plants</i>	1. Safety Reports Series No. 42 2. Safety Series No. 110 3. Safety Standards Series No. NS-R-2. 4. Standards Series NS-G-2.6 5. Safety Standards Series No. 50-SG-07
G-129, rev.1, <i>Keeping Radiation Exposures and Doses “As Low as Reasonably Achievable (ALARA)”</i>	1. Safety Series No. 21 2. Safety Series No. 102 3. Safety Series No. 103

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## Annex 7.2 (i) c

### Regulatory Framework for Small Reactors

A number of stakeholders have expressed interest in the possible construction of new small reactors. A small reactor is defined as a fission reactor with a thermal power of less than 200 MWt. Small reactors include reactors capable of producing radioactive isotopes, research reactors, steam production units, and small scale electrical power production units.

It is timely for the CNSC to update its regulatory framework in anticipation of the licensing of such projects in Canada. Two new regulatory documents addressing design requirements and deterministic safety analysis for small reactors are being developed. They are intended to follow the same approach as existing regulatory documents for large NPPS — *Design of New Nuclear Power Plants* (RD-337) and *Safety Analysis for Nuclear Power Plants* (RD-310). The regulatory documents for small reactors will be structured in the same way as RD-337 and RD-310, so that the similarities and differences are evident to users.

The regulatory document addressing design requirements for small reactors will identify the overall safety objectives to be achieved, key safety concepts (such as the principle of defence-in-depth), consideration of multiple physical barriers and other important engineering principles. System-specific requirements will also be described. Recognising that some requirements may not be relevant to all types of facilities, the document will also include an explanation of the graded approach (discussed below). These requirements will assure, during the preparation of a safety case for a licence to construct, that the design will be adequate and in accordance with defined regulatory requirements. The regulatory document will have similar requirements as CNSC document RD-337. However, it may have a different approach to some key technical areas, such as safety goals, confinement, security and robustness, and dose criteria for design basis accidents.

The regulatory document addressing deterministic safety analysis for small reactors will set out the technical criteria against which the CNSC will review deterministic safety analysis for small reactors. These criteria will assure that adequate safety analyses are completed for the siting, construction, operation and decommissioning of these reactors, in accordance with defined regulatory requirements.

#### Graded Approach for Small Reactors

To deal with the variety of small reactors in a wide range of designs, power levels and utilization, CNSC staff allows a licensee to use the graded approach introduced in IAEA document *Safety of Research Reactors* (NS-R-4, 2005). With the graded approach, the risk presented by the facility determines the stringency of how safety requirements are applied. For example, some small reactors may not require a confinement system as stringent as that used in conventional large NPPs.

An applicant for a licence related to a small reactor may use the graded approach to determine the scope, extent and detail to be followed for demonstrating the safety case. Such an approach reduces unnecessary burden on the applicant and facilitates the regulatory review process.

The safety requirements should be applied in such a way that the level of design, analysis, and documentation are commensurate with the potential hazards associated with the facility, without compromising safety. The design of any nuclear facility must provide the fundamental safety functions during and following a postulated initiating event such as controlling reactivity, cooling the reactor core and confining radioactive material. These safety functions are not gradable.

The extent and rigour of the demonstration that such safety functions are fulfilled vary depending on the reactor design. However, some small reactor designs may have inherent self-limiting power levels and/or systems that physically limit the amount of positive reactivity that can be inserted in the core. This feature may be used for grading the shutdown system design.

The extent of the cooling requirements will also vary depending on the reactor design. For example a forced convection cooling system to remove fission heat may be needed in one facility; in other facilities all fission heat may be adequately removed by natural convection cooling. Some facilities may need an emergency core cooling system to prevent damage to the fuel in the event of a loss of flow or loss of coolant accident; others may not need such a system.

Systems for confining radioactive material may also be graded. For example, some small reactors may not require a confinement system as stringent as that used in conventional large NPPs. The factors to be considered in the graded approach are as follows:

- the reactor power
- the source term
- the amount and enrichment of fissile and fissionable material
- spent fuel elements, high pressure systems, heating systems, and the storage of flammables, which may affect the safety of the reactor
- the type of fuel elements
- the type and the mass of moderator, reflector and coolant
- the amount of reactivity that can be introduced and its rate of introduction, reactivity control, and inherent and additional features
- the quality of the confinement structure or other means of confinement
- the utilization of the reactor (experimental devices, tests, reactor physics experiments)
- siting which includes proximity to population groups

## Annex 7.2 (iii) b Details Related to Verification of Compliance

The following table indicates some of the areas that are covered by Type II inspections at NPPs.

**Table 7.2 (iii) b.1: Specific Areas of Verification Activities**

Fuel handling	Control room
Startup	Reactor building
Shutdown safety	Turbine hall
Heat sinks	Battery room
Outage management	Control equipment room
Fuel and physics	Containment
Pressure boundary	Emergency coolant injection
Effluent control and monitoring	Shutdown System 1
Environmental monitoring	Shutdown System 2
	Stand-by safety systems
	Safety-related systems
	Electrical systems

Reporting requirements for all currently operating reactors are stipulated in operating licence conditions that cite CNSC document *Reporting Requirements for Operating Nuclear Power Plants* (S-99)

**Table 7.2 (iii) b.2: Reports Required from Operating NPPs per S-99**

Unscheduled Reports		Periodic Reports
Prompt Preliminary Reports Followed by Detailed Reports	Notifications and Other Reports	
<ul style="list-style-type: none"> <li>• non-compliances with the NSCA, regulations, orders, licence conditions</li> <li>• safety-significant non-compliances with licensing documents</li> <li>• deficiencies in records</li> <li>• events or incidents with significant implications for health and safety</li> <li>• releases</li> <li>• process failures</li> <li>• actuations, spurious operations, and degradations of safety systems</li> <li>• degradations, excessive load conditions (observed or calculated), failures, configuration contraventions of pressure boundaries</li> <li>• reductions in effectiveness of reactor and turbine control systems</li> <li>• emergencies</li> <li>• external events</li> <li>• failures to perform tests required by the licence</li> <li>• failures to monitor or control releases of nuclear or hazardous substances</li> <li>• hazards not addressed in licensing documents</li> <li>• changes in financial status</li> </ul>	<ul style="list-style-type: none"> <li>• reaching of action levels</li> <li>• performance and status of certified personnel</li> <li>• problems identified by research or analysis</li> </ul>	<ul style="list-style-type: none"> <li>• operations</li> <li>• performance indicators</li> <li>• facility description and safety analysis updates</li> <li>• environmental monitoring</li> <li>• research and development progress</li> <li>• periodic inspections</li> <li>• degradation of pressure boundaries</li> <li>• reliability</li> <li>• fuel monitoring and inspection</li> </ul>

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### Performance Indicators

One of the periodic reports required by S-99, as indicated in Table 7.2 (iii) b.2, is a report on performance indicator data. The CNSC performance indicators cover five performance areas of the NPP: operations, maintenance, public safety, worker safety and compliance.

The CNSC performance indicators are as follows:

- Accident Severity Rate, Accident Frequency
- Chemistry Index
- Chemistry Compliance Index
- Change Control Index
- Radiological Emergencies Performance Index
- Emergency Response Organization (ERO) Drill Participation Index
- Emergency Response Resources Completion Index
- Non-Compliance Index
- Number of Pressure Boundary Degradations
- Preventive Maintenance Completion Ratio
- Radiation Occurrence Index
- NPP Radiation Dose
- Number of Missed Mandatory Safety System Tests
- Number of Unplanned Transients
- Unplanned Capability Loss Factor

Some of the indicators can be used to measure the station performance as a whole, while some are more suited to measure performance in specific programs. Specification sheets that provide, among other things, the purpose and calculation method for the indicator, and data sheets have been developed to ensure standardized reporting. Definitions of the performance indicators and the data sheets are included in S-99.

These performance indicators have predictive or reactive attributes, or both. Predictive indicators measure trends and allow inferences to be made about any likely future deterioration in performance. They can, therefore, help identify potential problems, so corrective or preventive measures can be taken. Reactive indicators prompt immediate action to correct deficiencies and prevent further deterioration.

## Annex 10 a

### Safety Policies at the Nuclear Power Plants

As stated in Article 10, each NPP operator in Canada has established, as part of their management system, an over-riding priority to safety.

Each operating organization has chosen a different style of demonstrating its priority to safety, with some organizations choosing to state their high level safety principles as part of a distinct nuclear safety policy for their organization.

For example, the OPG nuclear safety policy states:

*“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.”*

The policy identifies the Chief Nuclear Officer as accountable for establishing a management system that fosters nuclear safety as the overriding priority.

Similarly the Bruce Power nuclear safety policy states:

*“Consistent with its value of Safety First, Bruce Power shall ensure that Nuclear Safety is always considered the overriding priority in its business decisions and activities. In this regard, it must carry out all activities with solemn acceptance of the responsibility we have to the public, each other, and the environment, as a consequence of our use of nuclear technology. As the operator of a nuclear plant, Bruce Power accepts that its fundamental nuclear safety objective is to protect the public, site personnel and the environment from harm, by establishing and maintaining effective defences against radiological hazards.”*

The Bruce Power nuclear safety policy provides additional elaboration related to the protection of safety margins, maintenance of defence-in-depth, and safety analysis.

At 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.”*

The *Nuclear Management Manual*, the highest-level document governing NBPN’s operations of Point Lepreau, has as the first point of the management commitment:

*“NB Power Nuclear is committed to the safe, reliable and efficient operation of PLGS.”*

The organization’s mission is stated as follows:

*“To operate the Point Lepreau Generating Station to provide electricity safely, ....”*

The first of the core values of the organization is stated as:

*“Safety First -- We recognize and take seriously the unique safety requirements of the nuclear core. 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 management system, and are also stated in the *Station Instruction on Operations Expectations and Practices*



## Annex 11.2 a

### Requirements for Qualification and Numbers of Workers

A hierarchy of laws and regulations specify the requirements for personnel who perform critical safety-related activities. These documents address the required number of staff, as well as their qualifications and training.

The Commission Tribunal can only issue licences to applicants that are qualified to operate the nuclear power plant (NPP) and will adequately provide for the health and safety of persons and the protection of the environment.

The NSCA provides the legislative basis for the certification, qualification, training and examination of personnel. In addition, the *General Nuclear Safety and Control Regulations* specify that the licensee shall:

- 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
- train the workers to carry on the licensed activity in accordance with the Act, the regulations made under the Act, and the licence

The *Class I Nuclear Facilities Regulations* require each applicant for a licence to provide details about the qualifications, training and experience of any worker involved in the operation or maintenance of the NPP. Requirements are in place for the application for a licence to construct, the licence to operate, and the licence to decommission.

The following requirements are included in NPP operating licences related to numbers of personnel, qualifications, and training:

- Enough qualified personnel (minimum shift complement) must be in attendance at all times, to make sure there is safe operation of the NPP. This includes ensuring a sufficient number of qualified personnel to complete all necessary actions to bring the reactor to a safe state. The minimum complement is specified in administrative documents that require CNSC approval for change.
- A sufficient number of the following certified positions must be in attendance at all times at an NPP, except as otherwise approved in writing by the CNSC. These will vary depending upon the design of the NPP:
  - authorized nuclear operator/control room operator (all multi-unit 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, and Darlington)
  - control room shift supervisor and shift manager for multi-unit NPPs
  - shift supervisor for single unit NPPs
- A certified responsible/senior health physicist must be appointed.
- Certified personnel must meet the relevant certification requirements applicable to their position, as specified in the CNSC document *Certification of Persons Working at Nuclear Power Plants* (RD-204).

- Significant changes to staffing and organization documents referenced in the licence must be approved by the CNSC before implementation.

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## **Annex 11.2 b**

### **Workforce Planning Process**

All licensees have processes to ensure that adequate resources and facilities are always available to respond to planned activities and contingencies. The following information, provided as an example, was submitted to the CNSC in 2009, in support of Bruce Power's licence renewal application.

In 2004, several work programs across the Bruce Power site were analysed to identify the number of tasks, time to complete tasks, and specific skills required.

This complemented the work already compiled by Bruce Power's training organization in conjunction with line organizations, which identified specific qualifications required to perform certain tasks, as well as the capability levels of employees assigned to these duty areas. This provided Bruce Power with an analysis of how many employees were required to manage current programs.

Additional analysis has been completed since that time, with external consultants that give Bruce Power a comprehensive view of the potential improvements that can be implemented to optimize its workforce.

The workforce planning process leverages this information in a talent segmentation exercise, and 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 develop a five-year hiring plan to mitigate risks to critical positions. An exhaustive 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 risk assessment/environmental scan of internal and external factors. In addition, the lead time (e.g., recruitment and training) has been identified for all critical positions (including certified staff) and serves as a basis for 'pre-hiring' before an incumbent actually leaves his/her position. This ensures that 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. Divisional Staffing Planning experts can review all business assumptions and hiring plan outputs from a desktop tool, and discuss emerging needs with the workforce planning team. Senior managers also review the status of Bruce Power's planned staffing efforts and other critical reports online.

Bruce Power's executive management sponsored a staffing-level benchmarking exercise that identified the staffing levels for specific jobs in top-performing plants. A separate benchmarking

report was compiled to highlight the best practices (procedures, programs etc.) carried out in these top-performing plants.

This body of knowledge is now applied to execute a gap analysis between the current staffing levels and the optimal future state. During Bruce Power's yearly business planning sessions, executives and senior managers reconcile current work program requirements and Bruce Power's long-term workforce model, to develop the appropriate staffing levels across site for each year of the planning horizon (e.g., five years).

Consequently, Bruce Power has plans in place to ensure that current programs are managed, while implementing improvement strategies to reach Bruce Power's future workforce model and staffing levels.

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## **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 focus on safety culture (discussed in Article 10), is 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.

All staff members are trained in error prevention techniques, to minimize the potential for errors. These techniques include multiple levels of verification of tasks and activities, event-free and behavioural tools such as three-way communication, a questioning attitude, self-check, pre- and post-job briefings, and procedural use and adherence, including approvals by qualified personnel. Communication protocols and reliable means of communication are provided between the control room and operating personnel at remote locations of the NPP to facilitate the performance of manual actions. Where possible, licensees ensure independent verification of actions or assessments prior to completion of work (e.g., system alignment verifications and post-maintenance testing following system manipulation or maintenance). This minimizes the occurrence of errors, and is a key step in mitigating the potential for human performance issues. Effective use of minimizes the chances of human errors.

Management's roles and responsibilities to aid in human performance include the following:

- clearly communicating performance expectations through policies and procedures
- establishing an effective organization with well-defined and understood responsibilities, accountabilities and authorities
- hiring sufficient numbers of properly qualified workers
- developing sound procedures to clearly define safety-related tasks
- continuously enhancing the procedures through incorporating lessons learned (see subsection 19 (vii))
- providing the necessary training and education to employees 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

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- 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

Each level of management is also vested with a specific level of authority as defined in the OP&Ps (see subsections 9c, 19 (ii), and 19 (iii)) and other 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 following:

- the limits of authority of the individual's position
- the applicable external requirements (e.g., laws, regulations and the licence) and internal boundaries (e.g., OP&Ps, safety reports, *Radiation Protection Regulations* 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 used 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 is provided, to assist managers and supervisors in directing their observation activities at 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 standards.

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## **Annex 12 b**

### **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 final detailed design, installation and commissioning phases. In operating NPPs, HFE considers operational, maintenance and decommissioning tasks, and is integrated in the development of procedures and into change control processes when any modifications are made.

A rigorous human factors engineering (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.

A systematic process is defined, documented and implemented, in order to integrate human factors into the design process. Human factors engineering program plans are produced to identify the HFE activities. The plans are based on the 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 the systems and equipment can be safely and effectively operated and maintained, for all postulated system states and operating conditions. Independent verification is carried out of the human factors input by qualified personnel, and the design is validated to ensure usability and suitability for the purpose. Human factors engineering summary reports are produced, to document the results of the human factors process.

In addition to providing input to the design itself, human factors are also addressed as part of the constructability, operability, maintainability, and safety review. Human factors are also considered in the development of procedures, instructions, and training.

## Annex 13 a

# Information Related to Quality Assurance Programs and Management Systems

### Definition of Safety-Related System

The requirements of the CSA-N286 series of QA standards apply to safety-related systems, which are defined as those systems, and the components and structures thereof, which, by virtue of failure to perform in accordance with the design intent, have the potential to impact on the radiological safety of the public or plant personnel from the operation of the NPP. Those systems, and the components and structures thereof, are associated with the following:

- the regulation (including controlled startup and shutdown) and cooling of the reactor core under normal conditions (including all normal operating and shutdown conditions)
- the regulation, shutdown, and cooling of the reactor core under anticipated operational occurrences and accident conditions, and the maintenance of the reactor core in a safe shutdown state for an extended period, following such conditions
- limiting the release of radioactive material and the exposure of plant personnel and/or the public, to meet the criteria established by the licensing authority with respect to radiation exposure during and following normal conditions, anticipated operational occurrences, and accident conditions.

The term ‘safety-related system’ covers a broad range of systems, from those having very important safety functions to those with a less direct effect on safety. The larger the potential radiological safety effect due to system failure, the stronger the ‘safety-related’ connotation. The term ‘safety-related’ also applies to certain activities associated with the design, manufacture, construction, commissioning, and operation of safety-related systems and to other activities which could similarly affect the radiological safety of the public or plant personnel. Such activities include environmental and effluent monitoring, radiation protection and dosimetry, and radioactive material handling (including waste management). The larger the potential radiological safety effect associated with the performance of the activity, the stronger the ‘safety-related’ connotation.

### Example Description of a Management System for an NPP

The Bruce Power Management System (BPMS) was designed first and foremost as a leadership tool for the Bruce Power organization. It articulates the way Bruce Power manages its business. The BPMS was chosen as a single integrated management system that covers five major components:

1. Strategic Direction
2. Policy, Program and Process Controls
3. Process Management
4. Business Planning and Monitoring for Results
5. Leadership Competencies and Organizational Accountability

The BPMS evolves with time so competitive advantages are maintained. The BPMS is reviewed, assessed and revised annually. The policies, programs, and procedures are continuously assessed to ensure corrective actions, benchmarked best practices, and all process innovations are



captured. No single element of the BPMS operates independently. All parts of the management system are interconnected and interdependent, and rest on a series of leadership principles.

The BPMS is a combination of the culture and inter-related activities used to direct and carry out work. It includes the way Bruce Power manages and supports its people, to enable them to deploy the processes established within the BPMS documentation, so that business objectives are achieved safely and efficiently. Objectives are achieved based on the integration of three basic concepts:

- Managers provide direction, resources, planning and support.
- Results are achieved by all staff performing work safely and in conformance with the documented requirements.
- The effectiveness of processes and work performance is assessed.

The BPMS describes how performance objectives are established and implemented.

Bruce Power has chosen to use its single integrated management system to satisfy certain safety, environmental and regulatory requirements, such as CSA standard *Management System Requirements for Nuclear Power Plants* (CSA N286). Bruce Power will maintain the BPMS, such that the portions that satisfy these requirements are specifically identified to a) explicitly demonstrate how the BPMS satisfies the requirement, and b) ensure that any changes that impact these portions of the management system are controlled, to assure ongoing compliance.

Clearly defined ownership and individual accountability is essential — the BPMS describes and reinforces this using a Governance-Oversight-Support-Perform model of accountability. The Bruce Power leadership team collectively owns the BPMS. The team also exercises specific ownership and direction of the organization's vision, values and behaviors, and key results areas.

Bruce Power operates as a private sector company, within a competitive electricity market. As such, it has an obligation to shareholders for operating the company in a manner that promotes optimization and expansion, in order to sustain the viability of the business while continuously enhancing shareholder value. Bruce Power also functions as a licensee of nuclear operating facilities, within a highly regulated environment. Managing the business within this environment requires the creation of an all-encompassing set of internal control arrangements, inclusive of policies, programs and procedures.

By design, the BPMS significantly contributes to the establishment of a safety culture that assures public/nuclear, environmental and worker safety. It also provides the necessary guidance for making risk-based decisions that satisfy the desired balance between safety, commercial and corporate reputation performance.

In developing this management system, Bruce Power has taken into consideration the applicable statutory, regulatory and licensing requirements, and has taken advantage of relevant industry standards and best practices, such as the Nuclear Energy Institute's Standard Nuclear Performance Model. The BPMS embraces the need for ongoing assessment and continuous improvement of overall system effectiveness. The BPMS shall be used as the basis for all work performed, decisions made and successes achieved.

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## **Annex 13 b**

### **Update on QA Measures for Pressure Boundary Work**

The third and fourth Canadian reports described the licensees' progress in implementing measures of QA programs prior to obtaining appropriate certification for pressure-boundary work. In the meantime, CNSC staff was limiting some licensees' authorization to perform pressure-boundary work, and/or requiring them to subcontract fabrication work to certified companies.

During the reporting period, the Ontario provincial authority for pressure boundary QA assessed Bruce Power's application for certificates of authorization for pressure-boundary work (repairs, replacements, modifications and fabrications to its non-nuclear and nuclear pressure-retaining boundaries). It was found that Bruce Power had successfully addressed new requirements for its QA programs, and the provincial authority subsequently awarded multiple certificates of authorization to Bruce Power. These certificates are scheduled for renewal in April 2010 at which time the QA program will be subject to a recertification assessment. Bruce Power also continued using contractors holding appropriate certifications for pressure-boundary work on major projects, such as those associated with the restart of Units 1 and 2. In 2009, Bruce Power's project management organization for Units 1 and 2 obtained additional certificates from the provincial authority for certain nuclear and non-nuclear fabrication and installation activities.

In 2004, the Ontario provincial authority for pressure boundary QA assessed OPG's application for certificates of authorization for pressure-boundary work (repairs, replacements, modifications and fabrications to its non-nuclear and nuclear pressure-retaining boundaries). It was found that OPG had successfully addressed new requirements for its QA programs. The provincial authority subsequently awarded nine certificates of authorization to each site, to cover the various scopes of work.

During the reporting period, CNSC staff and the Québec provincial authority for pressure boundary QA met regularly with Hydro-Québec representatives to discuss the new QA program relating to the pressure-retaining systems and components that Gentilly-2 intends to implement.

Point Lepreau has completed the revision of its management system to incorporate the required elements of National Board Inspection Code ANSI/NB 23-2004, RA-2360. The New Brunswick Department of Public Safety reviewed the management system documents, and issued a Certificate of Registration to Point Lepreau for its pressure boundary program. Point Lepreau is currently preparing for an implementation audit to finalize approval of the program.

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## **Annex 14 (i) a**

### **Content of the Safety Analysis Report**

The typical safety analysis report is organized into three parts, each of which deals with a separate aspect of the nuclear power plant (NPP).

Part 1 contains an introduction to the safety analysis report, a general description of the NPP, and a detailed description of the site. Typically, the site description in Part 1 includes the following characteristics:

- general description of the site
- geography of the site and land use for recreation and commerce, as well as information such as population distribution
- meteorology of the site
- hydrology of the site
- geology and seismology of the site

Part 2 describes the systems and components, in sufficient detail for understanding the interaction of the systems and for use in following the accident analysis details that follow in Part 3. Typical sections in Part 2 include the following elements:

- 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

Part 3 of the safety analysis report provides the detailed description of the accident analysis for the NPP. This part presents the analysis of all the design basis accidents, to demonstrate that the safety design objectives of all postulated accidents are met. Typical sections in Part 3 include the following:

- identification of initiating events
- fuel handling system failures
- electrical system failures
- control failures
- small loss of coolant accidents
- large loss of coolant accidents
- loss of coolant accident outside containment
- feedwater system failures

- steam supply system failures
- shutdown cooling system, shield cooling system and moderator system failures
- support system failures
- common mode incidents, such as:
  - 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

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## Annex 14 (i) b

### Status of Probabilistic Safety Assessments at Each Nuclear Power Plant

#### Bruce A and B

The Bruce A Probabilistic Safety Assessment (PSA) was completed in 2003 for Units 3 and 4 return-to-service. Subsequent updates of the Level 1 portion of the PSA in 2004 and 2006 have incorporated design and operational changes, and identification of the systems important to safety as required by the operating licence condition that cites CNSC document *Reliability Programs for Nuclear Power Plants* (S-98 Rev.1). In addition Bruce A had updated their PSA to include changes to the Units 1 and 2 refurbishment projects.

The scope of the Bruce A PSA included the assessment of the public health and economic risks arising from initiating events internal to the NPP. In addition, two externally initiated events were included: loss of offsite power and loss of common service water. The 2003 revision estimated severe core damage frequency to be  $4.8 \times 10^{-5}$  per year, and the large offsite release frequency to be  $1.0 \times 10^{-6}$  per year. Both risk estimates are below Bruce Power's risk targets and regulatory risk targets proposed by Bruce Power to CNSC.

The Bruce B PSA was updated in 2007. Its scope included the assessment of the public health and economic risks arising from initiating events internal to the NPP. In addition the effects of the loss of offsite power are analyzed. The 2007 revision estimated severe core damage frequency to be  $6.4 \times 10^{-5}$  per year, and the large offsite release frequency to be  $3.7 \times 10^{-7}$  per year. Both risk estimates are below Bruce Power's risk targets and the regulatory risk targets proposed by Bruce Power to CNSC.

OPG developed a PSA-Level 1 methodology applicable to both Darlington and Pickering plants, which has been accepted by CNSC. The methodology was submitted in anticipation of Darlington PSA-Level 1 submission, expected to be submitted later in the year.

#### Pickering A and B

In 1995, a PSA was completed for Pickering A that covered both Levels 1 and 2 for internal events with the units at high power and shutdown.

The Level 1 portion of the PSA was revised in 2006, and again in 2009, to reflect design changes, operating experience, and modifications related to the safe storage of Units 2 and 3 that affect Units 1 and 4. The 2009 revision of the PSA estimated severe core damage frequency to be  $3.6 \times 10^{-5}$  per year. This is well below OPG's risk targets and the regulatory risk targets proposed by OPG to CNSC.

A PSA was completed for Pickering B in 2006. The scope of the PRA included Levels 1, 2 and 3 for internal events, with the units at high power and shutdown.

The Level 1 and 2 portions of the PRA were revised in 2007, to accommodate design changes, improvements in methodology and operating experience. The 2007 revision estimated severe

core damage frequency to be  $2.1 \times 10^{-6}$  per year, and the large offsite release frequency to be  $7.2 \times 10^{-7}$  per year. Both risk estimates are well below OPG's risk targets and the regulatory risk targets proposed to CNSC.

The Pickering A and B PSAs will be comprehensively revised during the next reporting period, to incorporate current best practices, internal fires, internal floods and seismic events.

### Darlington

A PSA was completed for Darlington during its design and construction phase in the late 1980's. The PSA included an assessment of public health and economic risks arising from initiating events internal to the NPP. The PRA was used to demonstrate an acceptably low risk from operation, provide a thorough design verification, identify dominant contributors to risk, and assist in the preparation of operating procedures and surveillance programs.

An interim revision to the PSA was completed in 2001. This revision incorporated design changes and operating experience.

Starting in 2007, a thorough revision of the PSA began. This revision will:

- update methodology to industry standards and current Canadian regulatory standards
- incorporate design changes and operating experience
- expand the scope to include assessments for internal fires, internal floods, seismic events and other external events (e.g. aeroplane impact)
- include assessments for shutdown and high power units
- include Level 1, 2 and 3 PRA studies

The PSA is expected to be complete in the next reporting period. Initial results of the first phase — Level 1 PSA for internal events — indicate that the severe core damage frequency will be of the order of  $10^{-5}$  per year for high power units. This is well below both OPG's risk targets and the regulatory targets proposed by OPG to CNSC.

### Point Lepreau

A level 2 PSA for Point Lepreau, covering internal events and external events involving station fires and station floods, was issued in 2008. In addition, the shut-down state PSA for internal events and a PSA-based seismic margin assessment was produced. This particular assessment provides all the design insights expected of a seismic PSA, without making the results vulnerable to the large uncertainties typically encountered in site hazard input.

An important aspect of the PSA project was the CNSC's review of the various methodology documents before the PSA was performed. This provided an early opportunity to resolve any issues in view of compliance with CNSC document *Probabilistic Safety Assessment for Nuclear Power Plants* (S-294).

The main objective of the PSA was to provide insights into plant design and performance, including the identification of dominant risk contributors and the comparison of options for reducing risk to verify that the Point Lepreau refurbished station will meet current internationally accepted safety goals. The limits for severe core damage frequency and large release frequency

(LRF) for internal and external events are  $10^{-4}$  per year and  $10^{-5}$  per year, respectively, with a goal that is ten times lower. These are in line with the international targets for refurbished plants.

The level 1 PSA estimated severe core damage frequency at full power to be  $4.03 \times 10^{-5}$  per year. The level 2 PSA estimated the large release frequency at full power to be  $6.01 \times 10^{-7}$  per year. Details of the methodology of the PSA and the seismic margin assessment for Point Lepreau are provided below for information.

### Gentilly-2

Gentilly-2 does not currently have a full PSA. Various probabilistic studies were done as part of the original station design verification (known as safety design matrices), and reliability models have been developed for various systems important to safety. A full Level 2 PSA is being done as part of the Gentilly-2 refurbishment project.

### Example – Details of PSA and Seismic Margin Assessment Methodologies for Point Lepreau

For illustrative purposes, the following describes, in more detail, the conduct of the PSA for Point Lepreau.

The Point Lepreau PSA methodology incorporated the following features:

- Common cause failures in the fault tree analysis, using the Unified Partial Method (UPM).
- Human reliability analysis, related to pre- accident as well as post-accident operator actions. This analysis methodology is consistent with ASEP, which is a simplified version of the more analysis-intensive THERP method, developed by the U.S. Nuclear Regulatory Commission.
- Accident Sequence Quantification (ASQ) to evaluate frequency of the core damage related end states in each event tree.
- Uncertainty analyses on parameters such as: failure rates, component unavailabilities, initiating event frequencies, and human error probabilities. The uncertainties for each of these quantities are expressed in terms of probability distributions about their mean or best-estimate values.
- Sensitivity analysis to test the impact of certain changes in key input values (different maintenance practices, testing intervals, mission times etc.) to PSA results.
- Plant walk-downs, used to verify and supplement information contained in the fire and flooding database, and to provide a greater understanding of the failure modes of structures and equipment due to spatial interaction during a seismic event.

As mentioned above, Point Lepreau also performed a PSA-based seismic margin assessment. The PSA-based seismic margin assessment (SMA) follows the same procedure and steps as those of the seismic PSA, except for the treatment of seismic hazard information. Since the PSA-based SMA does not consider the seismic hazard explicitly, it does not produce severe core damage. Instead, the PSA-based SMA produces results such as the seismic capacity and random failure probability, given that seismic events occur. The major driving force to adopt the PSA-based SMA was the large uncertainty in the seismic hazard. Past seismic PSA experiences indicated that the dominant factor affecting the seismic-induced severe core damage frequency was the uncertainty in the seismic hazard, and not the seismic capacity of the NPPs. This finding

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made the decision making process quite difficult; consequently, it was proposed to use the PSA-based seismic margin assessment.

The tasks involved in the seismic margin assessment included:

- Establish seismic safety target defined in terms of plant HCLPF (High Confidence of Low Probability of Failure).
- Perform seismic fragility evaluation for structures and equipment which affect consequences or mitigation of the seismic event.
- Perform failure mode and effect analysis for seismic failures.
- Develop plant models.
- Generate minimal cutsets for seismic core damage sequences.
- Calculate the HCLPF value for each seismic core damage sequences.
- Perform uncertainty and sensitivity analyses for external events.



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## **Annex 14 (i) c**

### **Examples of Safety Improvements Being Implemented During Refurbishment of Point Lepreau**

In addition to the retube activities being conducted during the refurbishment of the Point Lepreau, the following upgrades have also been completed that lead to improve safety and are in various stages of commissioning:

- added additional shutdown system trip parameters and adjusted some trip set points to improve shutdown system trip coverage
- installed a third Class III electrical power standby diesel to support long term diesel maintenance
- installed a dedicated high efficiency particulate arrestor (HEPA) filter for the main control room to extend habitability during accident conditions
- installed 19 passive autocatalytic recombiners within the reactor building, to assist in hydrogen mitigation in the event of a loss of coolant accident in which emergency core cooling is not available

The following design changes, which are also being implemented during the refurbishment, help to address safety issues identified by the Point Lepreau Level 2 PSA:

- installation of passive autocatalytic recombiners (described above)
- procurement of spare parts for aux boiler feedwater pumps
- addition of fourth re-circulating cooling water pump
- addition of a heat transport pump trip on high upper-thrust bearing temperature
- implementation of numerous fire system improvements related to detection and suppression in key areas of the station (e.g., reactor, turbine and service buildings), egress in the turbine building, and provisions for enhanced fire testing
- installation of dyke to retain oil at heat transport pump troughs, in the event of oil fire.

The following design changes, also identified through the PSA, specifically address conditions during severe accidents:

- containment emergency filtered venting system
- calandria vault make-up system that provides for long term cooling of calandria vessel; this keeps calandria vessel intact, thereby preventing progression of the core debris to the vault and avoiding core concrete interaction
- sizing of calandria vault rupture disk for severe accidents
- post accident monitoring/sampling system

There were also several environmental qualification and seismic upgrades, procedural changes such as operating manuals and routines, and new or revised maintenance plans that help address issues identified by the PSA.

## Annex 15 a

### Detailed Requirements and Guidance for Control of Radiation Exposure of Workers and the Public

The regulations associated with the *Nuclear Safety and Control Act* (NSCA), include one set on radiation protection. The *Radiation Protection Regulations* include many of the ICRP-60 (1991) recommendations for dose limits, as well as ICRP-65 (1994) recommendations pertaining to occupational exposure to radon progeny.

The *Radiation Protection Regulations* address the following:

- implementation and requirements of licensee radiation protection programs
- the requirements for recording of doses
- the definition of action level and the actions to be taken when an action level has been reached
- informing workers of the risks associated with radiation to which the worker may be exposed, and informing workers of effective and equivalent dose limits
- the requirement to use licensed dosimetry services
- 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 nuclear emergencies
- actions to be taken when a dose limit is exceeded, and authorization of return to work
- requirements for licensed dosimetry services
- requirements for labeling of containers and devices
- requirements for posting of signs at boundaries and points of access

The NSCA gives the Commission Tribunal the power to authorize the return to work of persons who have exceeded a dose limit.

The CNSC has developed a number of regulatory documents to assist licensees in matters related to radiation protection and environmental protection. CNSC regulatory guide *Keeping Radiation Exposures and Doses “As Low As Reasonably Achievable” (ALARA)* (G-129), describes measures licensees can take to keep all doses to persons as low as reasonably achievable, social and economic factors being taken into account (ALARA). The elements that the CNSC considers to be essential in the approach to ALARA are summarized as follows:

- a demonstrated management commitment to the ALARA principle
- the implementation of ALARA through a licensee's organization and management, provision of resources, training, establishment of action levels, documentation and other measures
- regular operational reviews

The CNSC regulatory guide *Developing and Using Action Levels* (G-228) is intended to help applicants for CNSC licences to develop action levels in accordance with paragraph 3(1)(f) of the *General Nuclear Safety and Control Regulations*, and section 6 of the *Radiation Protection Regulations*. G-228 provides guidance on the types of parameters that can be used in developing

action levels, requirements for monitoring these parameters, and appropriate responses when an action level is reached.

Nuclear energy workers must be monitored for radiation exposure through a CNSC licensed dosimetry service. CNSC regulatory standard *Technical and Quality Assurance Requirements for Dosimetry Services* (S-106) contains accuracy, precision and QA requirements for dosimetry services licensed by the CNSC. S-106 either meets or exceeds the requirements of IAEA safety guides *Assessment of Occupational Exposure Due to Intakes of Radionuclides* (RS-G-1.2, 1999) and *Assessment of Occupational Exposure Due to External Sources of Radiation* (RS-G-1.3, 1999). Occupational dose results are submitted by the dosimetry service on a quarterly basis to the Canadian National Dose Registry, maintained by Health Canada.

## Annex 15 b

### Doses to Personnel at Canadian Nuclear Power Plants

The CNSC *Radiation Protection Regulations* reflect the 1990 recommendations of the International Commission on Radiological Protection (ICRP 60). Workers at Canadian nuclear power plants (NPPs) are restricted by dose limits of 50 mSv in any one year, and 100 mSv in a five-year period.

The data in the following table presents the collective dose from routine operations and from outages, as well as the total collective dose and the maximum worker dose at Canadian NPPs for the period of 2005–09. As indicated, no worker exceeded the annual dose limit of 50 mSv. In addition, although not indicated in the table, no worker exceeded the five-year dose limit of 100 mSv.

**Occupational Dose Summary from 2005 to 2009**

	Year	# of Reactors	Collective Dose from routine operations (person-Sv)	Collective Dose from outages (including forced outages) (person-Sv)	Total Collective Dose (person-Sievert)	Maximum Individual Dose (mSv)
<b>Bruce A &amp; B</b>	2005	6	0.980	7.71	8.69	19.99
	2006	6	1.012	4.81	5.82	12.27
	2007	6	0.976	7.93	8.90	16.28
	2008	6	1.026	9.87	10.89	17.53
	2009	6	0.911	6.14	7.05	13.35
<b>Darlington</b>	2005	4	0.377	2.48	2.86	12.44
	2006	4	0.353	2.85	3.20	28.30
	2007	4	0.343	3.76	4.11	32.42
	2008	4	0.220	1.52	1.74	17.21
	2009	4	0.256	2.94	3.20	21.05
<b>Gentilly-2</b>	2005	1	0.315	1.23	1.55	15.85
	2006	1	0.322	0.90	1.23	36.99
	2007	1	0.163	0.49	0.65	11.27
	2008	1	0.153	1.00	1.16	13.57
	2009	1	0.156	0.52	0.68	10.50
<b>Pickering A &amp; B</b>	2005	6	1.56	9.76	11.32	17.85
	2006	6	1.81	5.86	7.66	36.27
	2007	6	1.26	4.61	5.87	40.27
	2008	6	1.20	3.46	4.66	30.56
	2009	6	1.05	4.81	5.85	29.98
<b>Point Lepreau</b>	2005	1	0.137	1.44	1.58	17.86
	2006	1	0.156	0.75	0.90	12.1
	2007	1	0.129	0.54	0.67	9.2
	2008	1	0.055	5.94	6.00	23.1
	2009	1	n/a	4.08	4.08	15.9

**Collective Dose at Canadian Nuclear Power Plants**

Year	# of Reactors	Collective Dose (Sv)
2005	18	26.00
2006	18	18.81
2007	18	20.20
2008	18	24.45
2009	18	20.86

## **Annex 15 c**

### **Radiological Emissions from Canadian NPPs**

All NPPs release small quantities of radioactive materials in a controlled manner, into both the atmosphere (as gaseous effluents) and adjoining water bodies (as liquid effluents). This annex reports the magnitude of these releases for each operating NPP in Canada for the years 2006 to 2009. This annex also indicates how these releases compare with the DRLs imposed by the CNSC. The data show that, in the majority of cases, the levels of gaseous and liquid effluents from all currently operating NPPs are below 1% of the values authorized by the CNSC.

### Gaseous Effluent Release from Canadian Nuclear Power Plants (2006 to 2009)

	Tritium Oxide (TBq)	Carbon-14 (TBq)	Noble Gases (TBq-Mev)	Iodine-131 (TBq)	Particulates (TBq)
<b>Bruce A<sup>1</sup></b>					
DRL, Since 2001	8.8 E04	5.7 E02	5.0 E04	1.2 E00	2.1 E00
Since 2009	1.35 E05	1.06 E03	4.77 E04	1.26 E00	3.10 E-01
2006	4.5 E02	1.9 E00	1.2 E02	3.4 E-05	6.7 E-06
2007	9.3 E02	1.5 E00	1.5 E02	2.6 E-05	4.4 E-06
2008	1.2 E03	8.7 E-01	1.8 E02	1.8 E-05	3.5 E-06
2009	9.3 E02	7.9 E-01	1.1 E02	1.8 E-05	8.3 E-06
<b>Bruce B<sup>1</sup></b>					
DRL, Since 2001	9.3 E04	6.0 E02	1.2 E05	1.3 E00	2.5 E00
Since 2009	2.70 E05	1.08 E03	1.07 E05	9.80 E-01	7.44 E-01
2006	4.4 E02	10.0 E00	5.1 E01	1.0 E-04	1.1 E-04
2007	6.3 E02	5.7 E00	5.0 E01	1.2 E-04	1.1 E-04
2008	4.5 E02	4.8 E00	4.3 E01	3.8 E-05	9.6 E-05
2009	4.6 E02	1.7 E00	3.6 E01	4.2 E-05	1.1 E-04
<b>Darlington<sup>2</sup></b>					
DRL	4.3 E04	1.8 E03	3.9 E04	4.7 E00	2.4 E00
2006	1.30E02	1.20E00	1.40E01	1.20E-04	6.30E-05
2007	1.60E02	1.30E00	1.50E01	1.20E-04	5.90E-05
2008	1.60E02	1.70E00	1.80E01	1.10E-04	4.30E-05
2009	1.70E02	1.70E00	1.50E01	1.20E-04	5.40E-05
<b>Gentilly<sup>3</sup></b>					
DRLs	4.4 E05	8.8 E02	1.7 E05	1.3 E00	1.9 E00
2006	1.7 E02	2.8 E-01	7.2 E-01	Not detected	1.0 E-05
2007	1.5 E02	1.6 E-01	2.0 E-01	Not detected	Not detected
2008	1.7 E02	2.1 E-01	7.4 E-01	Not detected	1.0 E-05
2009	1.9 E02	3.0 E-01	2.5 E-01	Not detected	Not detected
<b>Pickering A<sup>2</sup></b>					
DRL, Prior to 2007	7.0 E04	1.8 E03	1.7 E04	2.2 E00	1.2 E00
Since 2007	5.5 E04	6.3 E03	2.0 E04	9.7 E00	2.1 E12
2006	2.80E02	1.36E00	1.27E02	1.25E-04	6.72E-05
2007	2.78E02	9.44E-01	8.18E01	3.94E-05	7.02E-05
2008	5.22E02	1.33E00	1.03E02	2.80E-05	6.55E-05
2009	4.40E02	1.18E00	2.09E02	2.32E-05	6.88E-05
<b>Pickering B<sup>2</sup></b>					
DRL, Prior to 2007	7.0 E04	1.8 E03	1.7 E04	2.2 E00	1.2 E00
Since 2007	5.5 E04	6.3 E-3	2.9 E04	9.7 E00	2.1 E12
2006	2.89E02	6.68E00	5.90E01	1.19E-05	3.45E-06
2007	2.78E02	1.11E01	7.67E01	6.82E-06	3.48E-06
2008	2.41E02	5.44E00	7.40E01	5.07E-06	3.96E-06
2009	2.62E02	1.32E00	6.36E01	5.51E-06	6.59E-06
<b>Point Lepreau</b>					
DRL	4.3 E05	3.3 E03	7.3 E04	2.2 E01	5.4 E00
2006	1.7E02	2.8E-01	3.9E0	Not detected	4.9E-09
2007	2.0E02	3.6E-01	4.3E00	3.7E-07	1.6E-09
2008	1.4E02	1.4E-01	5.6E-01	Not detected	Not detected
2009	3.2E01	5.9E-02	Not detected	Not detected	Not detected

<sup>1</sup> Since 2001, BP has reported the DRLs as interim DRLs. They were revised in 2001, mainly in response to changes in the public dose limit. The DRLs were updated in November 2009, when a comprehensive revision was completed.

<sup>2</sup> OPG has reported the DRLs as interim DRLs. They were revised in 2001, mainly in response to changes in the public dose limit. Darlington revised the interim DRLs in 2005, and adopted the comprehensive new DRLs since then. The DRLs for Pickering were updated in 2007.

<sup>3</sup> DRLs for Gentilly-2 are based on 5 mSv/year and are under revision.

### Liquid Effluent Release from Canadian Nuclear Power Plants (2006 to 2009)

	Tritium Oxide (TBq)	Gross Beta-Gamma (TBq)	Carbon-14 (TBq)
<b>Bruce A</b>			
DRL, Since 2001	4.5 E04	5.8 E-01	1.1 E01
Since 2009	2.13 E06	9.97 E01	2.61 E03
2006	3.0 E02	8.3 E-04	1.3 E-03
2007	1.7 E02	6.7 E-04	1.8 E-03
2008	2.4 E02	6.2 E-04	9.2 E-04
2009	2.5 E02	6.4 E-04	6.4 E-04
<b>Bruce B</b>			
DRL, Since 2001	6.0 E05	4.9 E00	9.1 E01
Since 2009	2.27 E06	1.06 E02	2.78 E03
2006	4.3 E02	3.9 E-03	6.2 E-03
2007	1.1 E03	2.9 E-02	5.1 E-03
2008	2.3 E02	4.1 E-03	3.6 E-03
2009	3.8 E02	2.7 E-03	3.5 E-03
<b>Darlington</b>			
DRL, Since 2005	4.3 E06	7.1 E01	9.7 E02
2006	1.90E02	4.80E-03	5.90E-04
2007	3.50E02	4.50E-03	7.60E-04
2008	3.90E02	4.50E-03	9.50E-03
2009	1.90E02	2.60E-02	3.90E-03
<b>Gentilly</b>			
DRL	1.2 E06	5.3 E00	1.0 E02
2006	2.3 E02	8.6 E-04	1.9 E-02
2007	2.0 E02	3.8 E-04	8.0 E-03
2008	3.7 E02	7.8 E-04	1.1 E-02
2009	3.4 E02	N/A	1.5 E-02
<b>Pickering A</b>			
DRL, Prior to 2007	1.7 E05	2.0 E00	See Note 1
Since 2007	5.10 E05	4.7 E00	6.4 E01
2006	1.31E02	5.03E-03	n/a
2007	7.05E01	7.23E-03	n/a
2008	2.50E02	1.69E-02	n/a
2009	1.51E02	1.78E-02	n/a
<b>Pickering B</b>			
DRL, Prior to 2007	1.7 E05	2.0 E00	2.6 E01
Since 2007	5.1 E05	4.7 E00	6.4 E01
2006	1.99E02	2.15E-02	6.20E-03
2007	1.82E02	3.18E-02	7.41E-03
2008	2.00E02	1.70E-02	3.64E-03
2009	2.45E02	7.70E-02	4.44E-03
<b>Point Lepreau</b>			
DRL	1.6 E07	1.5 E01	3.0 E02
2006	1.6 E2	1.4 E-3	2.4 E-3
2007	2.9 E2	3.9 E-2	1.2 E-3
2008	2.0 E3	2.3 E-2	2.6 E-2
2009	4.4 E1	3.2 E-4	2.1 E-4

Note 1: The carbon-14 releases in liquid effluent from Pickering A are reported in the carbon-14 liquid release data for Pickering B.



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## **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.

The Bruce Power Nuclear Emergency Plan deals with emergency situations that occur at Bruce A or Bruce B that endanger the safety of onsite staff or impact the protection of the environment and protection of the public. The emergency plan was conceived to deal predominantly with releases of radioactive materials from fixed facilities and the interfaces with the Province of Ontario Nuclear Emergency Response Plan (PNERP; see Annex 16.1 c). However, the infrastructure that is defined in the Bruce Power Nuclear Emergency Plan can be used in the planning and response to virtually all potential emergencies at the Bruce Power site.

The Bruce Power 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 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 to deal with the event.

The emergency plan is consistent with the corresponding Bruce Power nuclear safety analysis and reports that were provided to the CNSC in support of individual applications for CNSC construction and operating licences.

Security (or hostile action) response is dealt with through separate provisions, but provisions of this emergency plan still apply to deal with the associated potential threat of release of radioactive material (e.g., the need for offsite notification, situation updates, confirmation of any radioactive releases etc.) 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 for its stations.

In the event of an onsite nuclear emergency at a Bruce Power NPP, Bruce Power staff would immediately classify the nuclear emergency in accordance with criteria specified in the station emergency procedure. Should this emergency have offsite implications, Bruce Power staff further categorizes 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 process of program assessment. These exercises are conducted periodically at Bruce Power's NPPs, 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 those who live or work near Bruce Power NPPs, and certain Bruce Power employees and contacts who need to know. In the event of a nuclear emergency involving a Bruce Power NPP, Bruce Power 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 interest neighbours and other stakeholders, Bruce Power issues news releases and/or verbal briefings to the local media, with copies 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 the activation of the PNERP and the province of Ontario's joint emergency information centre (EIC), which is located in the Toronto offices of Emergency Management Ontario. Pending activation and operation of the EIC, Bruce Power's emergency response organization will, on an interim basis, communicate relevant information to the public and the media. With the EIC in operation, the provincial government assumes control of information services regarding the offsite response. The municipality of Kincardine will establish a local EIC at the municipality offices. Bruce Power assists the municipality of Kincardine with the preparation of information to the local public, to ensure accuracy. Emergency-related information prepared for issue at the local and provincial EICs is 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 OPG's Darlington and Pickering stations. 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 is designed to be compatible with the PNERP.

As for 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 public exceeding regulatory limits.

The OPG plan focuses on the release of radioactive materials from fixed facilities and on OPG interfaces with the PNERP (see Annex 16.1 c). The formal scope of the plan excludes hostile (security) action incidents at OPG nuclear plants, 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 confirmations of any radioactive releases.

The emergency plan is consistent with the corresponding OPG nuclear safety analyses and reports that were provided to the CNSC in support of individual applications for CNSC construction and operating licences.

To implement its nuclear emergency plan, OPG has developed site-specific nuclear emergency preparedness and response arrangements for its stations. 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 the station emergency procedure. Should this emergency have offsite implications, OPG staff further categorizes 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 OPG's overall process of program assessment. Exercises are conducted periodically at all OPG NPPs, in cooperation with other organizations and jurisdictions that have a role in nuclear emergency preparedness and response.

OPG maintains emergency public response capabilities within its nuclear public affairs department. The primary targets of 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 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. The OPG public affairs 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 interest neighbours and other stakeholders, OPG issues news releases or verbal briefings to the local media, with copies to provincial and municipal officials. If the situation warrants, 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 Centers (EICs). 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 the utility's arrangements to cope with actual or potential nuclear emergencies at its Gentilly-2 NPP. This 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.

1) Area alert:

- dangerous or potentially dangerous situation within a limited area of the power station

2) Station alert:

- dangerous or potentially dangerous situation within an important area of the power station

3) General alert level 1:

- significant radioactive materials released, or potentially released to the environment
- low risk to the population and the environment
- no protective measures required for the population
- declared by the Gentilly-2 authorities

4) General alert level 2:

- significant radioactive materials released, or potentially released to the environment
- significant risk to the population and the environment
- protective measures recommended for the population by Gentilly-2
- declared by the public authorities of the province of Québec

The Gentilly-2 plant conducts radiation emergency drills at least once per year. It 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 in accordance with a well-defined process.

The process includes these major activities:

- 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 relation framework
- training
- drills and exercises
- emergency preparedness implementation (risk assessment, alert declaration, emergency response organization activation, offsite authorities notification, 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 equipments
- tested emergency plans

### Point Lepreau Emergency Preparedness

NBPN provides emergency preparedness services in accordance with a process defined within the Point Lepreau nuclear management system. The process provides the capability to respond to radiological and conventional emergencies in a timely, effective and coordinated manner. The process scope includes all activities required for the preparation for, and response to, emergencies that could impact station personnel, the public or the environment, including necessary coordination with external organizations required to support any emergency response. The types of emergencies covered include radiation events involving releases onsite and to the environment (including transportation accidents involving nuclear substances), fire, chemical, medical, security incidents, and natural disasters such as storms, floods and earthquakes.

The New Brunswick Emergency Measures Organization (NBEMO), an agency of the provincial government, is responsible for actions to protect the public, and has processes for developing and testing the capability of its own plans and the coordinated response of other government agencies. The Point Lepreau process interfaces with the NBEMO plans and assists offsite authorities in dealing with radiation protection aspects of the NBEMO plan.

The Point Lepreau emergency preparedness process includes these key activities:

- preparation of the basis for emergency planning
- development and modification of the emergency response plan
- determining the resources required to implement the plan
- development of emergency response procedures
- implementing, maintaining and testing the response capabilities
- recognizing events that require emergency response
- mitigating the effects of events
- recovery from events in which emergency response was deployed

Inputs in to the process include:

- assessment of potential emergency scenarios arising from the station design and safety basis, station activities and materials
- coordination requirements with external emergency respondents and agencies
- relevant emergency planning and response legislation, regulations, standards and best practices, including standards and guidance from the Canadian Standards Association, National Fire Protection Association (NFPA), ICRP and IAEA

Outputs from the process are:

- tested emergency plans
- information for the public
- respondent emergency procedures

- maintained and designated emergency facilities and equipment

The emergency plan has three escalating levels of response to an incident requiring prompt response action:

- Alert: requires intervention of a trained response team, but is not of sufficient magnitude to interfere with activities throughout the station.
- Site area emergency: emergency conditions affect only the site area, within the NBP Point Lepreau property boundaries.
- General emergency: emergency conditions affect the environment, or potentially affecting the health and safety of persons outside the station property boundary.

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## Annex 16.1 c

### Provincial Offsite Emergency Plans

#### Province of Ontario

The province of Ontario possesses the greatest number of commercial power reactors (20) of any jurisdiction in Canada. In addition, a research reactor is located at Chalk River, and six U.S.A. nuclear facilities lie within 80 km of the province. As a result of these hazards, a nuclear emergency plan has been in place at the provincial level since 1986 (the Province of Ontario Nuclear Emergency Response Plan - PNERP). This plan has never been fully or partially 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 *Emergency Management and Civil Protection Act* governs emergency preparedness and response in Ontario. This legislation requires the government to formulate an emergency plan for emergencies arising in connection with nuclear facilities. It also permits the province to designate municipalities that shall plan for nuclear emergencies. Emergency Management Ontario (EMO), on behalf of the province, administers the PNERP and coordinates nuclear emergency preparedness and response in Ontario.

The PNERP defines a nuclear emergency as an actual or potential hazard to public health and property, or to the environment, from ionizing radiation whose source is a major nuclear facility within or immediately adjacent to Ontario. The hazard may be caused by an accident, malfunction, or loss-of-control involving nuclear radioactive material. The plan defines a radiological emergency as an actual or potential hazard to public health, property and/or the environment from ionizing radiation resulting from sources other than a major nuclear facility.

The aim of the plan is to safeguard the health, safety, welfare and property of the inhabitants of the province, and to protect the environment. The PNERP, as the lead document for offsite nuclear emergency preparedness and response, coordinates the activities of provincial ministries, nuclear facilities, the Government of Canada (including the CNSC), and designated municipalities in order to meet the objectives.

The PNERP details the arrangements in place for nuclear emergency planning, preparedness and response in Ontario. The plan covers various components, which include the following:

- aim and guiding principles
- hierarchy of emergency plans and procedures
- description of the hazard
- planning basis
- protective actions
- concept of operations
- emergency organization
- operational policies
- emergency information
- public education

- detailed responsibilities of the various participants
- provincial and municipal committee oversight

Full-scale provincial exercises focusing on nuclear or radiological emergencies are conducted regularly with participation from the Government of Canada.

In 2007, EMO began a comprehensive PNERP review process, expected to conclude in the next reporting period. The process involves, for each of the PNERP plans, a complete review and rewrite, consultation with stakeholders, and revisions based on stakeholder comment.

### Province of Québec

Within the province of Québec, the “Organisation de la sécurité civile du Québec” (OSCQ) is responsible for emergency planning and response to all hazards, including offsite nuclear emergencies. The “Plan national de sécurité civile du Québec” provides the terms of reference for all emergencies. The nuclear component of the OSCQ plan is described in a document entitled *Plan des mesures d’urgence nucléaire externe à la centrale nucléaire Gentilly-2* (PMUNE-G2), in accordance with the Québec provincial bill *Loi sur la sécurité civile*.

The PMUNE-G2 clearly defines the government agencies’ responsibilities in a nuclear emergency at the Gentilly-2 site, with the objectives of minimizing the consequences, protecting the public and providing support to the municipality’s authorities. In effect since 1983, the PMUNE-G2 is updated regularly. In 2002, response procedures and support programs were edited, and subsequently implemented. These are updated on a regular basis.

Under the PMUNE-G2, Hydro-Québec and the OSCQ have separate but complementary responsibilities for emergency planning and response to an accident at the Gentilly-2 site. As part of this response, with respect to PMUNE-G2, the OSCQ would open the government operations centre to coordinate the actions of the various government departments and organisations in Québec to maintain a link with the federal jurisdictions. The regional response centre located in Trois-Rivières would coordinate local responses and provide support to the affected municipalities.

The most recent information campaign on nuclear-related risks took place in March 2007, in parallel with the distribution of new potassium iodine pills to residents and workers in the urgent protective action planning zone within an 8 km radius around the Gentilly-2 NPP. A Web site ([www.urgencenucleaire.qc.ca](http://www.urgencenucleaire.qc.ca)) for sharing information was established. Furthermore, the municipalities within the 8 km zone are evaluating the procurement of an early population warning system. Between 2002 and 2005, the province of Québec purchased special detection and analysis equipment, capable of characterizing the environment and the food chain. Emergency response participants, who need to use them, undergo relevant training and exercises for their use on an annual basis.

The PMUNE-G2 master plan is being revised. The new version should be available in the next reporting period.



### Province of New Brunswick

The provincial nuclear emergency program is governed by a partnership between NBPN and the New Brunswick Department of Public Safety. Its primary agencies for emergency management and public security in New Brunswick are as follows:

- The New Brunswick Emergency Measures Organization (NBEMO), which is the provincial lead agency for emergency management and business continuity, including radiological-nuclear contingencies.
- The New Brunswick Security and Emergencies Directorate, which is the provincial lead agency for security and critical infrastructure protection.

The Government of New Brunswick has consolidated public safety and public security responsibilities under the mandate of the Department of Public Safety. The highlights are as follows:

- strengthening the prevention, 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, more fault-tolerant and to improve capacity
- updating and strengthening operational capability at the provincial (NBEMO) Joint Emergency Operations Centre, including enhancements to the business process, investments in infrastructure to improve connectivity and collaboration among federal and provincial intervening organizations, and more focus on operational readiness
- development of a training and exercise strategy for major scenarios, including nuclear response, so that the provincial nuclear emergency organization 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 Centre and the Joint Emergency Operations Centre

Under the *Emergency Measures Act*, the 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 stated aim of the plan is to designate responsibility for actions to mitigate the effects of any emergency, other than war, in the province of New Brunswick.

The plan defines the lead responsibilities of the Department of Public Safety and the supporting roles of some 23 departments, agencies or organizations. Representatives of these players make up the Provincial Emergency Action Committee (PEAC), which directs, controls and coordinates provincial emergency operations, and assists and supports municipalities as required.

The PEAC maintains two states of readiness. The standby state is a state of readiness that requires representatives of departments to be available on call. An emergency state is a state requiring action from NBEMO and/or other departments. During an emergency state,

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departmental representatives are called to headquarters and briefed on the corresponding emergency.

The province is divided into eight emergency measure organization districts. Emergency measure organization district coordinators stimulate 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, district emergency committees are formed to provide assistance to municipalities and the populace of unincorporated areas. These committees consist of representatives from the departments of Environment, Health, Justice, Natural Resources, Social Development and Transportation, 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 district emergency committee. District emergency operations centres are located in government facilities.

The NBEMO developed the Point Lepreau Offsite Emergency Plan, in accordance with the framework described above. It delineates the roles and responsibilities of, and the immediate actions to be taken by, those involved if an incident at Point Lepreau creates an offsite emergency.

If it is necessary to alert the public to the occurrence of an offsite emergency, wardens will oversee designated areas to ensure residents are appropriately informed of any actions required of them. An automated telephone and email notification system has been established to send messages to all residents. As well, radio, television and wardens will advise the public of the need for any protective actions. Arrangements are in place to help individuals who may require physical assistance should evacuation prove necessary.

The NBEMO is currently developing a provincial radiological emergency plan for non-nuclear events.

The Government of New Brunswick has implemented a new provincial Incident Management System, comprising 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 (Radiation Protection Bureau) and the Department of National Defence.

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## Annex 16.1 d

### Provisions of Federal Emergency Plans

#### Provisions of the Federal Nuclear Emergency Plan

Within the Federal Nuclear Emergency Plan (FNEP), a nuclear emergency is defined as an event that has led or could lead to a radiological threat to public health and safety, property, and the environment.

The FNEP contains the following information:

- outlines of the Government of Canada's aim, authority, emergency organization, and concept of operations for dealing specifically 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
- annexes that describe interfaces amongst federal and provincial emergency management organizations, and the arrangements for a coordinated response and the provision of federal support to provinces affected by a nuclear emergency

There are four types of nuclear emergency events covered by the FNEP:

- an event at an NPP in Canada or in the U.S.A., along the Canada-U.S. border
- an event involving vessels visiting Canada or in transit through Canadian waters
- an event involving a NPP in the southern U.S.A. or in a foreign country
- other serious radiological events

In addition to the events listed above, the FNEP includes appendices that summarize the onsite emergency notification classifications adopted by Chalk River Laboratories in Ontario, all NPPs in Canada, and selected NPPs in the United States for both airborne and liquid releases.

The scope of the FNEP excludes the following situations:

- circumstances of war, such as the military use of nuclear weapons against North America
- events that may pose a limited radiological threat, and consequently are not expected to exceed the response capabilities of regulatory, local or provincial authorities
- management and coordination of the Government of Canada's actions during the recovery phase; if federally assisted recovery actions are required as a consequence of a nuclear emergency, the responsibility for these actions is to be assigned to a specific minister of the Government of Canada, during or immediately following the response phase of the nuclear emergency

Québec, Ontario, Nova Scotia, New Brunswick and British Columbia are the Canadian provinces most likely to be affected by a nuclear emergency, as defined in the FNEP. This higher probability is due to their closer proximity to American and Canadian NPPs, and the existence, within their boundaries, of NPPs or ports that are visited by nuclear-powered vessels.

As the Chernobyl accident demonstrated, a severe nuclear emergency at a major NPP that is distant from Canada would have a limited effect. Although small quantities of radioactive material might reach Canada, they would be unlikely to pose a direct (e.g., from exposure to fallout) threat to Canadian residents, property or environment. Consequently, Canada's response under the FNEP to a nuclear accident at an NPP in the southern United States or in another foreign country would likely focus on the following:

- controlling food imported from areas near the accident
- assessing the impact on Canadians living or traveling 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 events, as defined in the FNEP, will 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 factors such 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.

#### Introduction of Emergency Management Act

In June of 2007, the Government of Canada replaced the former *Emergency Preparedness Act* with the modernized *Emergency Management Act* (EMA). The EMA is intended to provide clearer direction for federal government ministers and their respective departments/agencies, and broadened the scope of emergency preparedness at the federal level to include all aspects of emergency management.

As a result of this change, CNSC staff undertook a review and gap analysis of the current state of emergency management at the CNSC and the implications of the new EMA. The analysis consisted of a review of the EMA, compared with the CNSC emergency management program. Although some gaps were identified, it was found, in general, that the CNSC emergency management program aligned well with the EMA.

#### Provisions of the Regulatory Body in Emergency Preparedness and Response

The CNSC participates in nuclear emergency prevention, preparedness, response and recovery activities, as part of its responsibilities according to Canadian legislation.

During a nuclear emergency in Canada, the CNSC would continue in its regulatory role, as anticipated in the Federal Nuclear Emergency Plan (FNEP) and the CNSC Emergency Response Plan.

Since the CNSC's regulatory obligations extend to a wide range of circumstances, stations, 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 (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 emergency operations centre operates using public electricity, and it can also rely on an emergency generator in the event of loss of the electricity grid (blackout), such as the event of August 14, 2003. The CNSC has an alternate site for emergency staff to assemble, should its main headquarters not be accessible.

To fulfill the CNSC *Nuclear Emergency Management Policy* (P-325) and the CNSC Emergency Response Plan, emergency management relies on staff to assess the significance of an emergency and to communicate these findings to senior management, staff, the public, media, the licensee and all levels of government.

The CNSC Emergency Response Plan is the document that describes the strategies and guidelines that the CNSC will follow to cope with a nuclear emergency. It describes:

- emergency situations that could require CNSC involvement
- the role of the CNSC in nuclear emergencies
- the role of interfacing parties
- the CNSC emergency preparedness organization
- the concept of operations
- the CNSC equipment infrastructure
- preparedness and training requirements and exercises

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 federal *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. The plan draws upon provisions of the *Packaging and Transport of Nuclear Substances Regulations* and the *Transportation of Dangerous Goods Act* and regulations, and it includes formal agreements with various organizations and jurisdictions.

Ultimately, the implementation of the CNSC Emergency Response Plan in the event of a declared emergency could involve the following parties:

- the CNSC emergency organization
- CNSC employees
- CNSC licensees
- transporters, shippers and others involved in, or affected by, the transport of nuclear substances
- departments and agencies of the Government of Canada
- provincial government departments and agencies
- news media organizations
- the United States Nuclear Regulatory Commission
- the IAEA

The CNSC Emergency Response Plan is in effect at all times, in one of four operating modes: normal, standby, activated, or recovery.

- In the normal mode, the CNSC plans, trains and exercises to maintain its emergency preparedness. In this mode, the CNSC also responds to events that do not warrant activation of the emergency organization.
- In standby mode, the CNSC alerts responders and monitors the status of events that may require an emergency response at some stage.
- The CNSC Emergency Response Plan enters the activated mode of operations when the CNSC decides that an emergency response is necessary, and activates preparations for such a response.
- The recovery mode follows the activated mode, and consists of activities to restore a non-emergency state, such as the standby or normal modes.

Within the context of the CNSC Emergency Response Plan, a nuclear emergency is any abnormal situation associated with a radiological activity, or a CNSC-licensed activity or facility that could require prompt action beyond normal procedures, in order to limit damage to persons, property or the environment.

These nuclear emergencies could be offsite or onsite emergencies. For example, a nuclear emergency could be created by events related to the following situations:

- the release, or potential release, of radioactive contaminants or any nuclear substance prescribed in the NSCA from a Canadian or foreign NPP or other CNSC-licensed facility
- the loss, theft, discovery or transport of nuclear substances within or outside of Canada

The nature of the above involvement could range from exchanging ideas and information to coordinating plans, attending training programs, participating in exercises, and responding to actual emergencies. The CNSC Emergency Response Plan provides corporate guidelines for employee involvement.

The CNSC Emergency Response Plan defines the CNSC staff members in the emergency organization 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 CNSC's Emergency Response Plan, the CNSC has established various technical and administrative arrangements. They include bilateral cooperation agreements with other national and international jurisdictions, as well as operation of a CNSC duty officer program, whereby anyone can seek emergency information, advice, or assistance 24 hours a day, for actual or potential incidents involving nuclear materials or radiation.

In keeping with national policy, and notwithstanding its participation in the FNEP, the CNSC Emergency Response Plan continues to be an important evergreen document that ensures the CNSC is well aligned with new nuclear emergency management processes introduced by stakeholders.

In the summer of 2009, the CNSC and Emergency Management Ontario revised an existing Memorandum of Understanding to capture recent changes for both organizations. This continues to be an important agreement between the organizations, to ensure there is a clear understanding of each other's role and responsibilities before, during, and after a radiological and nuclear emergency in the province of Ontario, and for potential trans-boundary events.

The CNSC is in the process of adopting a similar approach with the province of Québec and the province of New Brunswick, to ensure that such agreements are in place.

## Annex 17 (ii) a Environmental Assessment Process

An environmental assessment (EA) is initiated following an application under the *Nuclear Safety and Control Act* (NSCA) for a licence or a licence application/amendment for a life extension project for an existing facility, and is carried out under the *Canadian Environmental Assessment Act* (CEA Act). EAs identify whether a specific project is likely to cause significant environmental effects, and ensure that potentially significant adverse effects are identified and mitigated to the extent possible. By considering environmental effects and mitigation early in project planning, environmental factors are considered in decision making, and the potential delays and unnecessary costs can be avoided or reduced. The CNSC is required to carry out an EA when it is considering issuing or amending a licence under sections 24(2), 37(2)(c) or 37(2)(d) of the NSCA (as indicated in the CEA Act's *Law List Regulations*) for a proposed project.

In the context of licensing a new NPP or life extension project, this means that before any licensing decision can be made, an EA must be completed with a decision that the project is not likely to cause significant adverse environmental effects. If the decision on the EA is negative, the project will likely not proceed to licensing.

A proposal to construct a new NPP generating more than 25 MW (thermal) is subject to a comprehensive study-level EA, in accordance with the CEA Act's *Comprehensive Study List Regulations*. The CEA Act allows for projects undergoing either a screening or a comprehensive study EA to be referred to a mediator or a review-panel, based on a request from the Commission Tribunal to the minister of the Environment, or directly by the minister of the Environment, when:

- it may cause significant adverse environmental effects, after taking into account mitigation measures
- it is uncertain whether a project will cause significant environmental effects, given the implementation of mitigation measures, or
- public concerns warrant such referral

To date, NPP proposals have been directly referred to a review-panel level of EA by the minister of the Environment, based on the Commission Tribunal's recommendations.

If a decision is made to refer a proposed NPP to a review-panel level EA, the CEA Act provides for one of the following three approaches to be taken for establishment of the panel:

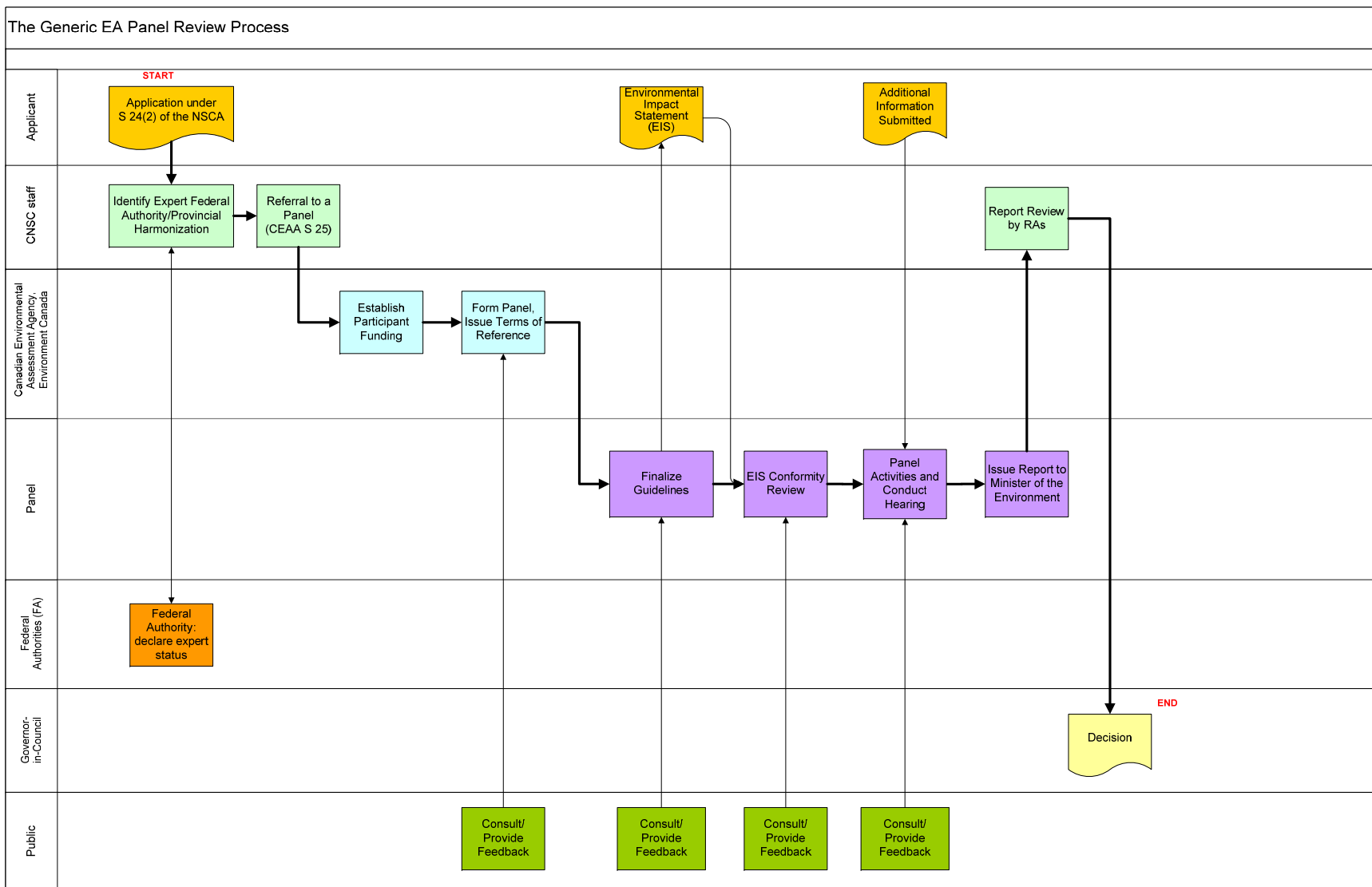
- a Canadian Environmental Assessment Agency-only review panel, whereby the EA is conducted by a panel appointed by the minister of the Environment, in consultation with the responsible authority (the Commission Tribunal)
- a substitution arrangement, whereby the Commission Tribunal process is used as a complete substitute for a review-panel review under the CEA Act
- a joint CNSC-Canadian Environmental Assessment Agency process, whereby the review panel conducts the EA (under the CEA Act) and considers an application for a licence to prepare site (under the NSCA). The panel is appointed by the minister of the Environment and the president of the CNSC, and consists of the Commission Tribunal



(represented by one or more members) and outside appointees. Those outside appointees are made temporary members of the Commission Tribunal by the governor in council, in order to fulfill their duties under the NSCA. A joint review process could also include another jurisdiction where appropriate (e.g., a province)

The following figure provides a graphic representation of the generic EA panel review process.







The procedures for the conduct of the panel review would depend on the approach selected, but would incorporate, as appropriate, the procedures set out in the 1997 ministerial guidelines entitled *Procedures for an Assessment by a Review Panel*, available at [ceaa-acee.gc.ca/013/0001/0007/panelpro\\_e.htm](http://ceaa-acee.gc.ca/013/0001/0007/panelpro_e.htm)

A panel review involves these key documents:

- Terms of Reference of the panel: issued by the Minister of the Environment, following consultation with the responsible authorities and the public
- Environmental Impact Statement (EIS) Guidelines: developed by federal departments and agencies or the panel, after public consultation, and issued to the licence applicant
- EIS report: prepared by the licence applicant, in response to the requirements of the EIS Guidelines
- Report of the Review Panel: prepared by the panel following public hearings, submitted to the Minister of the Environment, and made available to the public
- Government Response to Report of the Review Panel (i.e., panel's recommendations): prepared by a lead federal department (usually a responsible authority), in consultation with other federal departments, and submitted for approval by the governor in council, before being released to the licence applicant and the public

Life extension projects for existing NPPs are subject to screening-level EAs under the CEA Act. In January 2009, CNSC revised its process for screenings, which is described in CNSC document [Environmental Assessment Screening Process at CNSC](#) (INFO-0774). As the responsible authority, the CNSC determines the scope of the screening EA. Documentation generated during CNSC's screening EA process includes the CNSC's Scoping Information Document, the EA Technical Studies (prepared by the applicant), and the EA Screening Report (prepared by the CNSC).

When a project is subject to an EA by several jurisdictions, there may be a need to harmonize the federal EA process with provincial EA requirements, in order to coordinate EA activities where possible (e.g., multi-jurisdictional screening, joint review panel with a province) and avoid duplication of work. Given the potential for such situations, the federal minister of the Environment has entered into EA cooperation agreements with other Canadian jurisdictions. These agreements provide guidelines, for example, on procedural aspects and the roles and responsibilities for each jurisdiction, in the assessment of such projects.

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## **Annex 17 (ii) c**

### **Examples of Outreach Conducted by Applicants for a Licence to Prepare Site**

For the Bruce Power new-build application related to the Bruce site, Bruce Power conducted a thorough communications and consultation program, employing an open and transparent process. The communications and consultation program was designed to provide the community, other stakeholders and Aboriginal peoples, with opportunities to gain knowledge about the project and provide input to the environmental assessment (EA) process.

The communications and consultation program was developed in conformity with the EA Guidelines, which define the scope and depth of the required EA studies, and were approved by the Joint Review Panel. The program included the following objectives:

- Identify affected and interested community members, stakeholders and Aboriginal peoples.
- Deliver project and EA information.
- Provide opportunities for community members, other stakeholders and Aboriginal peoples, to identify their concerns and issues and provide their input.
- Encourage early information sharing by participants.
- Improve the EA process and the project by incorporating community and traditional knowledge, as well as public ideas and opinions.
- Address issues and concerns.
- Demonstrate how issues and concerns have been addressed in the EA process.

The consultation activities included the host municipality, five neighbouring municipalities and the nearest city (Owen Sound). In addition, community members and other stakeholders, such as elected representatives and interested parties who had indicated an interest in previous Bruce Power EAs, or had jurisdictional responsibility in the outreach area, but who live outside the outreach area, were consulted.

Prior to the formal commencement of the EA, Bruce Power engaged the two First Nations (Aboriginal) communities in the regional study area, to communicate with respect to the planning process considering new reactors on the Bruce Power site and discuss the participation of local First Nations in the process.

Correspondence with all levels of government was an important aspect of the EA process. Several meetings, workshops and other consultation activities were held with various government agencies, including CNSC, Environment Canada, the Ontario Ministry of the Environment, and the federal Department of Fisheries and Oceans.

Consultation methods and outreach activities undertaken for the new-build EA included notification advertisements and letters, newsletters, community updates, open houses, stakeholder briefings, library repositories, Web site and email consultations, and a toll-free information line.

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OPG conducted a similarly thorough outreach, related to its application to prepare a site for the Darlington new-build project. Its goal was to ensure that the views and perspectives of the community, residents, Aboriginal groups and the public were considered in the EA for the Darlington new-build project. Multiple activities were conducted, including:

- nine direct mailings to over 95,000 households and businesses in Clarington and Oshawa
- over 6,500 residents engaged through DNNP EA participation in 37 community events (fairs, trade shows etc.)
- over 1,800 visitors to OPG's new-build EA community resource centre (kiosk) at the Bowmanville Mall
- 38 community information sessions in the regional study area, with over 1,000 participants
- over 100 stakeholder interviews with community organizations in Durham Region
- special initiatives for Darlington nuclear site neighbours, including
  - site neighbour interviews/surveys
  - 'kitchen table' meetings with over 30 site neighbours
  - surveys with recreational users, particularly Darlington site recreational users and Darlington Provincial Park users
  - creation of the Darlington Planning and Infrastructure Information Sharing Committee, regarding other planned projects in South Clarington
- regular updates (letters and briefings) to 13 regional and municipal councils, existing community committees (Durham Nuclear Health Committee, Darlington Site Planning Committee, Pickering Community Advisory Committee), as well as other stakeholder and Aboriginal groups
- formation of an Aboriginal Relations Working Group to ensure continual progress on the implementation of OPG's policy on Aboriginal relations
- invitation of 11 Aboriginal communities, Métis councils and organizations to participate in numerous roundtable discussions and site tours.

All of OPG's materials were also posted on its public Web site.

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## **Annex 17 (iii) a**

### **Examples of Measures Taken by Licensees to Re-evaluate and Address Site-related Factors**

#### Climate Change Example – Bruce A & B

The two most likely impacts of climate change on NPPs is an increased frequency of severe weather events and changing lake water levels.

Despite the apparently greater number of severe weather events recorded since 1970, these events have not affected the operation of the facilities at Bruce A and B. The facilities have considered the potential effects of extreme weather in their design, and have been constructed to withstand the effects of such events. Therefore, increases in the frequency of severe weather events that could potentially be related to climate change should have no effect on the NPPs over their operating life.

Under a changed climate, potential effects on the lake water balance may occur due to changes in the precipitation/evaporation patterns. The potentially adverse effects on sustaining lake levels due to increases in seasonal temperatures (increased evaporation) are expected to be largely offset by the seasonal increases in precipitation predicted in the modelling. Thus, there is no expected adverse impact on the stations at Bruce A and B over the course of their operating lives.

Studies undertaken for the Bruce Power new-build environmental assessment (EA) reviewed the possible affects of climate change on the valued ecosystem components that were defined for the proposed site. The studies covered all areas of the environment, including air quality and noise, aquatic environment, terrestrial environment, and hydrology and water quality. The EA determined that some valued ecosystem components may change over the lifespan of the project as a result of climate change; however, none of the changes would have a significant impact on the facility during its operating life.

#### Fish Impingement and Entrainment Example - Pickering

To reduce fish impingement and entrainment at Pickering, a barrier net was installed around Pickering intakes in 2009. The net is removed from mid-November to mid-April, due to icing conditions, rough lake winter conditions, and unsafe conditions for divers to conduct routine maintenance of the net (about three times per week). The overall barrier net effectiveness is expected to be about 86% over the year, including when the net is removed for the winter months. The CNSC has set an impingement reduction target of 80%. OPG is conducting an effectiveness assessment of the barrier net and its impact on the annual Pickering fish impingement and entrainment quantities. This will include a combination of representative sampling and assessing actual fish impingement and entrainment, with and without the fish barrier net in place, for an annual cycle of four seasons.

CNSC staff and the Canadian Department of Fisheries and Oceans have permitted OPG to proceed with the fish monitoring and impingement and entrainment quantification methodology, and the placement of acoustic sonar equipment. OPG is considering fish stocking and coastal wetland habitat enhancement to address the fish impingement and entrainment issue, and to provide protection while the barrier is not operational during the winter months.



## Annex 18 (i)

### Design Features and Principles in Existing CANDU NPPs Related to Defence-in-Depth

The following are some important examples of implementing the elements of the defence-in-depth approach in the design of the CANDU reactors currently operating in Canada.

#### Accident Prevention

The first and most important principle of defence-in-depth is accident prevention; that is, ensuring a low probability of operational failure of a system or component. This is accomplished by the following practices:

- applying sound engineering practices during the siting, design, construction and operation of an NPP
- using proven technologies
- designing, building and maintaining the NPP according to recognized codes and standards
- ensuring plant staff are appropriately trained
- employing appropriate quality control and QA methods in all phases of design, manufacturing, construction, and operation
- performing periodic inspection and testing of components and systems
- monitoring events in other similar facilities to anticipate problems before they occur

#### Barriers to Radioactive Releases

In CANDU design, most of the radioactive material resides in the fuel elements. There are five barriers between this material and the public, as enumerated in the following list.

1. Uranium Oxide Fuel: The fission products are produced and trapped in the solid fuel matrix. More than 99% of them remain in the fuel and are never released under normal conditions. Only a fraction of 1% of these fission products escape the uranium oxide and are then contained within the fuel sheath.
2. Fuel Sheath: It retains the small amount of volatile fission products that escape the fuel matrix.
3. Heat Transport System (HTS): The fuel is contained in the HTS. An intact HTS retains the fission products even if sheath failures occur and the small amounts of fission products (usually known as free-gap inventory) that reside between fuel and the sheath are released.
4. Containment System: The next barrier to the releases is the containment system, which contains radioactivity if both the fuel sheath and the HTS fail.
5. Exclusion Zone: It provides atmospheric dilution of any fission product releases from the containment if all of the other barriers are breached.

In CANDU design (see first and second Canadian reports for details), the two protective shutdown systems, the emergency core cooling (ECC) system and containment system are combined into a single category of ‘special safety systems’. Canadian NPPs typically include additional protective equipment (separate from and independent of the special safety systems) in order to make sure that there is an acceptably low frequency of challenges to the safety systems. Examples of such

process-protective equipment involve the setback and stepback functions of the reactor regulating system, which are designed to cope with some reactor control failures without requiring action by the safety shutdown systems.

### Redundancy

Redundancy is the use of two or more components or systems that are each capable of performing the necessary functions. System redundancy is achieved by having independent systems perform equivalent functions. In the CANDU ‘two group’ design concept, two groups of selected safety-related systems are provided in the NPP, each of which can maintain the NPP in a safe state and perform the essential safety functions of NPP shutdown.

The NPP systems are divided into two basic groups as follows:

- **Group 1 Systems:** systems that provide a safety function to mitigate an event and that also perform a safety function or power production function during normal station operation; Group 1 includes these systems:
  - power production systems
  - one group of special safety systems
  - a set of safety support systems
- **Group 2 Systems:** systems that provide a safety function to mitigate an event and perform no function during normal station operation are allocated as Group 2 systems wherever possible; the following systems are included in Group 2:
  - the second group of special safety systems
  - a second set of safety-support systems

Besides redundancy of the groups of systems, component redundancy is built in to the special safety systems to satisfy the single failure criterion. Special safety systems satisfy an unavailability target of  $10^{-3}$ , which effectively requires redundancy of all critical components. Regular tests of special safety systems components verify the availability of these systems during operation.

The first step in defining safety system design requirements is to identify the initiating events and event combinations that place the most severe demands on the systems. Generally, this involves a combination of judgement, knowledge of results of analyses of previous plants, and the selected scoping analyses. The selected initiating events are then analysed in detail.

In addition, existing CANDU NPPs are designed for dual failures, which consist of a design-basis initiating event along with coincident unavailability of one special safety system. This means that an NPP is designed, for example, to mitigate a LOCA combined with a loss of ECC injection by using the moderator system as an alternate means of fuel cooling.

Process systems also make extensive use of redundancy to improve station availability in the production of electrical power. This redundancy minimizes the frequency of serious process failures.

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### Diversity

Diversity is the use of two physically- or functionally-different means of performing the same function. It provides protection against certain types of common-mode failures, such as those arising from design or maintenance errors.

Providing two different shutdown systems for CANDU reactors is a good example of diversity. The design concept of system diversity is also used in the design of independent emergency cooling water and power systems provided via the two-group approach.

### Separation

The separation of special safety systems from the systems used for power production (process systems) is a fundamental safety principle and a regulatory requirement in Canadian practice. It ensures that events affecting a limited area of the station and functional interconnections between systems do not impair the capability to perform required safety functions under accident conditions.

Separation refers to the use of barriers or distance to separate components or systems that perform similar safety functions. Therefore, if a failure or localized event occurs in or near one system or component, it is unlikely to affect the other. Separation provides protection against common-mode or cross-linked effects such as fires and missiles.

Physical and functional system separation is designed into the two-group concept in CANDU NPPs. The components of special safety systems that perform similar functions are separated to the maximum practicable extent, and redundant components within systems are physically separated according to their susceptibility and common hazards. Specific requirements are applied to the triplicated instrument cables and the duplicated power and control cables for safety-related systems. The odd and even concept of on-site power distribution is applied to equipment, the raceway system and junction boxes to maintain physical separation between the odd and even systems. This results in maximum reliability under normal and abnormal conditions.

### Mitigation of Accidents

The defence-in-depth approach also requires provisions and procedures to be in place to mitigate the consequences of accidents. These include measures to prevent fuel failure following a serious process failure as well as provisions to contain radioactive materials in the event of fuel failures. Accident mitigation is achieved by incorporating:

- multiple barriers as described in subsection 18 (i)
- measures to protect these barriers from damage due to accidents
- reliable and effective special safety systems into the design that are capable of limiting the consequences of accidents

Mitigation of accidents also includes building redundancy and diversity, to continue providing important safety functions, such as electric power and heat removal, even after some components have failed as a result of an accident. Examples of this include:

- the auxiliary steam-generator feed pumps, the shutdown cooling system and the emergency water systems, all of which are capable of removing heat from the reactor

- a secondary control room, for use should the main control room be unavailable for any reason
- redundant electrical power supplies and service water supplies to essential equipment

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## **Annex 18 (ii)**

### **Example Application of State-of-the-art Technology for CANDU—Passive Autocatalytic Recombiners**

An example of the application of state-of-the-art technology for CANDU is the research, development and implementation of passive autocatalytic recombiners for all Canadian CANDU NPPs.

It had been determined that hydrogen released by pressurized heavy water reactors (such as CANDU) during certain accident sequences could produce flammable gas mixtures in some regions of containment. The mechanical and thermal loads generated by the ignition of these gas mixtures could challenge the integrity of the containment envelope, supporting internal walls and required safety-related equipment.

The CNSC raised a generic action item (GAI 88G02) to implement adequate hydrogen mitigation measures for design basis accidents. GAI 88G02 was closed during the reporting period; see Appendix G for details.

AECL and Point Lepreau undertook a project to develop and evaluate a prototype set of passive autocatalytic recombiners. After initial testing, the testing program was expanded to expose the recombiner plates to various CANDU containment conditions in addition to laboratory conditions. The results of these tests were shared with the Canadian COG members resulting in a technical basis for implementation of passive autocatalytic recombiner units at all Canadian NPPs. In addition to the experimental testing and verification of the units, long-term hydrogen mixing analyses were performed for all Canadian CANDU NPPs to determine the number and location of units in containment. Passive autocatalytic recombiner units are now being installed at other Canadian NPPs to address the potential hydrogen safety issue.

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## **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.

The CNSC staff does not attempt to participate in 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 QA. Detailed commissioning specifications define the acceptance criteria to be used in the inspections and tests performed as part of the commissioning program. Typically, the licensee's procedures require the designers to approve commissioning specifications for a particular system or component, 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

The commissioning QA plan 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 what, if any, design changes are required. This allows the CNSC staff to 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 test of the plant's response to a loss of normal electrical power supplies). CNSC staff also witness major commissioning tests of special safety systems, such as functional tests of the shutdown systems where the reactor is actually tripped and the rate of power reduction is measured (and compared to the rate assumed in safety analyses).

In other 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, while commissioning tests were done involving 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.

When reviewing commissioning, CNSC staff concentrates on these major tests, because they are considered particularly important to safety. These tests check the overall performance of an NPP's safety features, and can reveal problems that tests of individual components would not detect. CNSC staff also reviews test proposals, including the 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 reviews the test results and commissioning reports.

The CNSC requires the licensee to submit commissioning completion assurances before the first loading of fuel, first loading of heavy water, and the first criticality of the reactor. 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.

Typically, the licensee holds a series of commissioning completion assurance meetings, to review the work done on particular systems. The CNSC staff at the site attends some of these meetings.

The completion assurance statements may contain lists of tasks not yet completed, such as the completion of commissioning reports that are not prerequisites to the approvals being sought. These lists of incomplete items are helpful to ensure that these tasks are not subsequently overlooked.

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## Annex 19 (iv)

### Progress on Implementation of Severe Accident Management Guidelines

The Canadian NPP licensees took steps in 2002 to form a Severe Accident Management working group, coordinated by the CANDU Owners Group (COG), with the objective to formulate severe accident management guidelines (SAMG) for CANDU reactors, based on international best practices. The emergency operating procedures at that time addressed a number of accident situations well beyond design basis accidents; however, they tended to focus on the use of equipment and systems within the scope of their intended purpose and within the constraints of normal operating rules. The Severe Accident Management project is intended to extend the scope of severe accident management beyond these procedures, in the event that significant core damage occurs or is imminent, in order to take all reasonable measures, with any available equipment, to mitigate core damage and releases from containment. The objective is to provide better guidance to control room staff, to manage and exit severe accidents.

In parallel with the first phase of the COG SAMG project, CNSC published a regulatory guide, *Severe Accident Management Programs for Nuclear Reactors (G-306)*, in 2006.

The first phase of the COG SAMG project concluded early in 2007. It adapted the Westinghouse Owners Group approach to severe accident management for use in CANDU reactors, producing a set of generic guidelines applicable to all operating CANDU models, and then a more focused set of guidance documents for each of the CANDU models (CANDU-6, Pickering and Bruce/Darlington). The COG brought the project to the attention of overseas members, providing the opportunity for all CANDU-6 reactor operators to participate in and benefit from information developed during the project.

The licensees adapted the generic SAMG strategies and guides to each NPP.

The second phase of the Severe Accident Management project, also coordinated by a COG working group, will see the implementation of the project documents by the utilities, adapting the SAMG strategies and guides to each specific site and operating organization, interfacing the SAMG with the control room emergency operating procedures, validating the SAMG documentation against a wide variety of scenarios, and providing the emergency response organization with training necessary to implement severe accident management strategies during emergencies. Exercises to verify the effectiveness of the developed strategies and documentation will focus initially on potential core damage scenarios, identified by probabilistic safety assessments as constituting the highest residual risk. This implementation phase commenced in 2007, with the implementation validation exercises for various plants expected to continue into the next reporting period.

The implementation of SAMG at NPPs in Canada is in various stages of completion at the different facilities. The following summarizes that progress for each NPP.



### Bruce Power

During the reporting period, Bruce Power issued the SAMG governing procedure and implementing documents. Training development and delivery to operations and emergency response staff was initiated, with a validation exercise completed in 2009. Bruce Power is progressing with the implementation of key elements of a SAMG program for Bruce A, prior to the return to service of Units 1 and 2. The key elements include a User's Guide, two Control Room Guidelines, a Diagnostic Flow Chart, a Severe Challenge (hazard) Status Tree, seven Severe Accident Guidelines, four Severe Challenge Guidelines, six Computational Aids and two Severe Accident Exit Guides. In support of these elements, the plan includes a number of enabling procedures and minor design changes. To date, the SAMG program document has been issued, training of operations and emergency response crews completed and a SAMG exercise drill has been performed.

Development of SAMG for Bruce B has been initiated with preparation of an implementation plan.

### OPG

OPG has undertaken a two phase approach to SAMG implementation. Phase 1, or emergency response organization implementation, was the focus during this reporting period. OPG has developed station-specific guidance, including a User's Guide, Control Room Guidelines, a Diagnostic Flow Chart, a Severe Challenge (hazard) Status Tree, Severe Accident Guidelines, Severe Challenge Guidelines, Computational Aids and Severe Accident Exit Guides.

Training programs, including a SAMG overview and an in-depth SAMG user program, were developed and delivered to key members of the Emergency Response Organization. The full suite of SAMG documentation has been made available in Emergency Response Organization facilities. A Darlington-specific SAMG drill was held at the OPG Corporate Emergency Operations Facility to verify the effectiveness of the developed strategies and documentation. A Pickering-specific drill is planned for the next reporting period. OPG plans to complete Phase 1 implementation by the end of 2010 and has assembled a SAMG team to join the Emergency Response Organization duty roster.

Phase 2, or station implementation, will involve integration of SAMG with the existing NPP emergency operating procedures, further development of enabling instructions, field walkdowns and design changes. Phase 2 planning is underway for each OPG NPP and the work will commence during the next reporting period.

### Point Lepreau

Point Lepreau is progressing with the implementation of key elements of a SAMG program, which include the update of emergency preparedness procedures and operations procedures, technical and management team training, severe accident guides and severe challenge status tree and diagnostic flow charts. The completion of the SAMG implementation project is expected in the next reporting period, with the integration into the Emergency Preparedness program and the publication of the report that evaluates the first SAMG exercise.

### Gentilly-2

During the reporting period, Hydro-Québec continued to study options for SAMG. It is anticipated that the CNSC will set conditions for SAMG at Gentilly-2, as part of the refurbishment project.

Gentilly-2 is awaiting official confirmation of the refurbishment decision before making a decision on SAMG. In anticipation of a positive response, Hydro-Québec is expecting to study possible options for SAMG, and the licence renewal and refurbishment process will provide further insights into its development.

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## Annex 19 (vii)

### Programs to Collect and Analyze Information on Operating Experience

Programs to collect and analyse information on operating experience (OPEX) are established, the results obtained, and the conclusions drawn are acted upon. Existing mechanisms are used to share important experience among the CANDU industry and with international bodies, and other operating organizations and regulatory bodies.

#### Operating Experience Feedback Systems

The process of collecting, analysing, and disseminating lessons learned from information arising from the OPEX is known as a feedback process or system. Feedback systems established by the licensees in Canada are normally part of the licensees' QA program. The licensees' OPEX feedback systems also involve the CNSC, CANDU Owners' Group (COG), Atomic Energy of Canada Limited (AECL) and other organisations.

#### Requirements and Obligations

CSA document *Operations Quality Assurance for Nuclear Power Plants* (CSA-N286.5), which is cited in most NPP operating licences, calls for measures to make sure that operations experience is documented, assessed and incorporated into the operation of the NPP and/or its QA programs, as appropriate. It also calls for making this information available to personnel in the other phases of the NPP's lifecycle. Under this clause, the CNSC has been conducting inspections in NPPs and licensee's corporate offices, to make sure that the existing feedback systems achieve their objectives.

#### Sources of Information

Station condition records or event reports, submitted by the licensees in accordance with CNSC document *Reporting Requirements for Operating Nuclear Power Plants* (S-99), are the primary source of information. Other licensee reports include the licensees' quarterly reports, in-service reports and internal audit reports. On the regulatory side, the CNSC issues inspection reports on NPP operations in nuclear power stations. These reports contain the CNSC inspection findings, and the deficiencies that the licensees are required to correct.

International sources include the IRS and International Nuclear Event Scale (INES) reports from the IAEA. The CNSC provides internet access to these reports to all Canadian NPP licensees.

#### Channels of Feedback

The licensees have developed feedback systems to integrate OPEX into all aspects of NPP operation and management. For example, NBPN has developed the Problem Identification and Corrective Action system, while OPG has an OPEX site that incorporates SCRs and operating experience from the World Association of Nuclear Operators (WANO), the Institute of Nuclear Power Operators and COG sites. Similar systems exist at other Canadian NPPs. AECL has implemented a similar system for its research reactor facilities at Chalk River.

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COG provides an information exchange program, to enhance excellence in the safety, reliability and economic performance of CANDU plants worldwide by sharing OPEX. A weekly OPEX screening meeting teleconference, chaired by COG, serves as a CANDU screening committee to review event reports from CANDU stations and nuclear industry sources for applicability and significance to CANDU units. The screening committee consists of OPEX staff from OPG (Darlington, Pickering and Head Office), Bruce Power, Gentilly-2, Point Lepreau, Cernavoda, Embalse, Wolsong, AECL, WANO, and COG. Each site presents information about recent events at its location that may be relevant to the other sites. COG presents nuclear industry reports that are screened from sources such as WANO, IAEA and the United States Nuclear Regulatory Commission. OPEX feedback from Indian and Pakistani reactors comes through WANO participation in the COG OPEX screening meeting, as well as IAEA reports screened by COG.

Nuclear industry reports obtained through COG are systematically collected, recorded, reviewed, and distributed by AECL for further evaluation. CANDU owners share safety and regulatory issues via the regularly scheduled Regulatory Feedback Team meeting for CANDU NPP owners, chaired by AECL. The purpose of this feedback forum is to ensure that design, analysis, construction, commissioning, and operating experience is communicated to all CANDU operators, and that emerging issues are fed into new CANDU designs. Sources of information include AECL new reactor design projects, operating plants (Canadian and international), and international OPEX and regulatory activities (US Nuclear Regulatory Commission, IAEA, Western European Nuclear Regulators' Association etc.). Quarterly reviews and meetings include staff from AECL project groups, Canadian NPP licensees, and COG. The disposition of discoveries may include advisory notices or action notices issued by the chief engineer of AECL to the CANDU industry.

The CNSC staff maintains a database to collect, screen, store and retrieve operational data. It includes records of events reported by the licensees, in accordance with CNSC regulatory standard S-99. The CNSC staff reviews and trends these events, in order to aid in the regulatory oversight of the NPPs.