Canadian National Report for the Convention on Nuclear Safety

Sixth Report
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Canadian National Report for the Convention on Nuclear Safety - Sixth Report

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Canadian National Report on Nuclear Safety
Sixth Report

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

Executive Summary

This sixth Canadian report demonstrates how Canada continued to meet its obligations under the terms of the *Convention on Nuclear Safety* (the Convention) during the reporting period from April 2010 to March 2013. 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 – which focus on the health and safety of persons and the protection of the environment – are implemented by the nuclear regulator, licensees of nuclear power plants (NPPs) and other government institutions and industry stakeholders. Canada remains fully committed to the principles and implementation of the Convention.

Twenty CANDU reactors were operating in Canada during the reporting period, including reactors at Bruce A and Point Lepreau that were returned to service following their refurbishments for life extension. The refurbished units underwent many design and other enhancements that will improve their safety to a level approaching that of new-build projects. In support of the decision to refurbish Darlington (which may begin as early as the end of the next reporting period), an environmental assessment (EA) and integrated safety review (ISR) were completed. An ISR is a one-time application of a periodic safety review (PSR). An ISR was also conducted for the incremental life extension of Pickering B. Plans were put in place to continue and sustain the safe operation of all operating units at Pickering A and B until their scheduled shutdown by the end of 2020. The shutdown of Gentilly-2 commenced toward the end of the reporting period and detailed plans were initiated for its decommissioning. Work on new-build projects also continued – the CNSC issued a licence to prepare a site for as many as four new reactors at the existing Darlington site, following the positive conclusion of the EA.

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. To further enhance this system, the CNSC continued its licence reform project – by the end of the reporting period, all existing NPPs had streamlined operating licences and accompanying licence condition handbooks (LCHs) that clarify the regulatory requirements and expectations and facilitate increased regulatory effectiveness and efficiency.

The CNSC has a comprehensive program to assure compliance with the regulatory framework and monitor the safety performance of the NPPs. A comprehensive set of graduated enforcement

tools are available to the CNSC to address non-compliances. An additional tool was introduced during the reporting period – administrative monetary penalties (AMPs) – that will enhance the CNSC's effectiveness and flexibility in enforcement.

The CNSC's regulatory framework and processes feature a high degree of openness and transparency. The CNSC continued to enhance openness and transparency during the reporting period, e.g., by establishing a participant funding program to facilitate the participation of eligible intervenors in the decision-making process and by issuing discussion papers and soliciting early public feedback on potential regulatory changes.

The Canadian NPP licensees fulfill their responsibility to safety, and give it high priority at every level of their organizations. The licensees and the CNSC make a strong ongoing commitment to nuclear safety and strive to continuously improve it.

The Canadian regulatory framework, which is largely non-prescriptive, is continuously updated and aligned with international standards (as a minimum). Renewals of operating licences for NPPs are used to introduce new standards and requirements that the licensees actively implement. During the reporting period, the CNSC continued to develop the regulatory framework for both refurbishment and new-build projects. The CNSC further enhanced its readiness for new-build projects by conducting vendor pre-project design reviews, participating in the Multinational Design Evaluation Programme (MDEP), and completing staff work instructions to support the assessment of licence applications.

The International Atomic Energy Agency (IAEA) Integrated Regulatory Review Service (IRRS) completed a follow-up peer-review mission to Canada in 2011. This mission assessed the CNSC's response to findings from the initial IRRS mission in 2009 and also assessed two other areas – the regulation of transport of radioactive materials and the regulatory response to Fukushima. The peer-review team concluded that the CNSC had conducted appropriate follow-up to the findings of the initial mission and that the vast majority of the recommendations and suggestions from 2009 could be considered addressed and closed.

Canada has a mature nuclear industry, with an excellent safety record. During the reporting period, NPP licensees fulfilled the basic responsibilities for safety as required by the NSCA, regulations, and the NPP operating licences. Safety issues that arose were addressed by the licensees to keep the risk 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. 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 percent of derived release limits. The CNSC ratings of NPP safety performance under the 14 CNSC safety and control areas confirmed that regulatory requirements and performance expectations in all safety and control areas were met or exceeded at all NPPs for all three years of the reporting period, with only a very small number of exceptions back in 2010.

Canada responded effectively to the Fukushima nuclear accident and is applying the lessons learned to improve safety. The CNSC issued requests to the licensees to confirm the safety case for each facility and to address the lessons learned from Fukushima. After assessing the responses and examining its own regulatory framework, the CNSC developed an action plan with clear deliverables in the short, medium and long terms for both NPP licensees and the CNSC. The numerous activities to address the actions have included:

- deterministic and probabilistic safety assessments
- revisions to regulatory documents
- enhancements to modelling and analysis tools
- installation of new equipment that enhances defence in depth
- upgrades to emergency plans
- proposals to amend regulations
- procurement of emergency mitigating equipment and backup power
- conduct of large-scale emergency exercises
- enhancements to near-boundary radiation monitoring

and many others. All the short-term actions were completed and all remaining actions are scheduled for completion during the next reporting period.

The CNSC's response to Fukushima was assessed by independent reviewers as prompt, comprehensive and effective, and as taking into account the various lessons learned from the accident. In addition to the Fukushima review during the follow-up IRRS mission in 2011, the CNSC also established an External Advisory Committee (EAC) of independent regulatory experts to assess its regulatory response to Fukushima. These reviews identified specific findings that complemented the CNSC Action Plan (in particular, related to emergency preparedness, communications, and human and organizational factors). The CNSC incorporated activities to address these findings in its integrated action plan, which covers not only NPPs but other regulated nuclear facilities.

Overall, the actions taken by Canada will address the lessons learned from Fukushima and help prevent a similar accident or help mitigate its effects should it occur.

During the reporting period, the CNSC and Canadian nuclear industry addressed the three specific challenges that were identified for Canada at the Fifth Review Meeting:

Challenge C-1	Continue implementation of PSR
Challenge C-2	Overcome potential human resource shortages related to refurbishment and new-build projects
Challenge C-3	Complete implementation of severe accident management guidelines (SAMGs)

During the reporting period, the CNSC decided that PSR should be integrated into the NPP licensing process (e.g., on a 10-year cycle) with the results becoming part of the licensing basis for the NPP. The CNSC is planning to update its regulatory document *Life Extension of Nuclear Power Plants* (RD-360), which includes requirements for ISRs. The revision will stipulate the periodic performance of the comprehensive ISR process in conjunction with licence renewal. Recognizing the value of PSR, Darlington has committed to its implementation in support of long-term operation, with the first full PSR submission to the CNSC planned for 2014.

Significant human resource shortages are not expected to materialize in the foreseeable future. The demand for human resources decreased during the reporting period (e.g., due to decisions to close Gentilly-2 and to not refurbish Pickering B, as well as a longer-than-anticipated time frame for the Province of Ontario to decide to proceed to the new-build construction phase). The NPP industry has extensive and effective programs related to training, staffing, examination, workforce capacity evaluation, hiring, knowledge retention, and research and development to ensure the sufficiency of human resources for current and planned activities. Furthermore, the CNSC has optimized its workforce to meet existing and anticipated regulatory needs.

SAMGs have been implemented at all operating NPPs. In the case of Gentilly-2, Hydro-Québec is developing a specific program for the irradiated fuel bay while the NPP proceeds towards decommissioning. During the reporting period, the NPP licensees incorporated SAMGs into their existing emergency plans and are validating them, or have already validated them, in emergency drills and exercises. In response to the lessons learned from Fukushima, the licensees are pursuing additional enhancements to SAMGs, such as expanding their scope to include multi-unit events and irradiated fuel bay events.

Table of Contents

Acronyms, Abbreviations and Specific Expressions

ACR	Advanced CANDU Reactor
action level	A specific dose of radiation or other parameter that, if reached, may indicate a loss of control of part of a licensee's radiation protection program and triggers a requirement for specific action to be taken
AECL	Atomic Energy of Canada Limited
AIA	authorized inspection agency
ALARA	as low as reasonably achievable
AMP	administrative monetary penalty(ies)
ANSI	American Nuclear Standards Institute
ASB	auxiliary services building
ASME	American Society of Mechanical Engineers
BEAU	best-estimate analysis and uncertainty
BPMS	Bruce Power Management System
Canadian report	The [n^{th}] Canadian report refers to the [n^{th}] *Canadian National Report for the Convention on Nuclear Safety,* submitted on behalf of Canada for the [n^{th}] Review Meeting of the Convention on Nuclear Safety.
CANDU	Canadian Deuterium-Uranium
CCP	commissioning control point
CEAA	*Canadian Environmental Assessment Act*
CERTS	Central Event Reporting and Tracking System
CIIT	CANDU Industry Integration Team
CMD	Commission member document. Each CMD is prepared for Commission hearings and meetings by CNSC staff, proponents and intervenors and is assigned a specific identification number.
CNS	Convention on Nuclear Safety
CNSC	Canadian Nuclear Safety Commission
CODAP	Component Operational Experience, Degradation and Ageing Programme
COG	CANDU Owners Group (Inc.)
Commission	The tribunal component of the Canadian Nuclear Safety Commission.
CRL	Chalk River Laboratories
CSA	Canadian Standards Association, now called CSA Group
desktop review	All verification activities limited to the review of documents and reports submitted by licensees (including quarterly technical reports, annual compliance reports, special reports and documentation related to design, safety analysis, programs and procedures).
DFAIT	Department of Foreign Affairs and International Trade
DNNP	Darlington New Nuclear Project

DPRR	Directorate of Power Reactor Regulation (CNSC)
DRL	derived release limit
DSS	Directorate of Security and Safeguards (CNSC)
EA	environmental assessment
EAC	External Advisory Committee
EC6	Enhanced CANDU 600
EIS	environmental impact statement
EMA	*Emergency Management Act*
EMO	Emergency Management Ontario
EOC	Emergency Operations Centre (CNSC)
EPR	European Pressurized Reactor
EPRI	Electric Power Research Institute (U.S.)
ERO	emergency response organization
event review	All verification activities related to reviewing, assessing and trending of licensees' event reports.
FERP	Federal Emergency Response Plan
FNEP	Federal Nuclear Emergency Plan
focused inspection	A special Type I or Type II inspection that is performed as a regulatory follow-up in response to an event, inspection findings or a licensee's performance.
FPTRPC	Federal Provincial Territorial Radiation Protection Committee
FSIIT	Fukushima Safety Improvement Implementation Team
G8	Group of eight nations (Canada, United States of America, France, United Kingdom, Germany, Italy, Japan and Russia and representatives of the European Union).
GAI	generic action item
Harmonized Plan	The corporate improvement plan for the CNSC that integrates and aligns all cross-functional improvement initiatives into a single, prioritized plan with clear deliverables.
HFE	human factors engineering
HR	human resources
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiation Protection
INES	International Nuclear Event Scale
INPO	Institute of Nuclear Power Operations (U.S.)
IRS	Incident Reporting System
IRRS	Integrated Regulatory Review Service
ISO	International Organization for Standardization (also referred to as International Standards Organization)
ISR	integrated safety review
LBLOCA	large-break loss–of-coolant accident
LCH	licence conditions handbook
LOCA	loss-of-coolant accident
MDEP	Multinational Design Evaluation Programme

MoU	memorandum(a) of understanding
mSv	millisievert
MW	megawatt
MWe	megawatt (electrical)
NAYGN	North American Young Generation in Nuclear
NBEMO	New Brunswick Emergency Measures Organization
NBPN	New Brunswick Power Nuclear
NEA	Nuclear Energy Agency (OECD)
NEO	Nuclear Emergency Organization (CNSC)
NEWS	Nuclear Event Web-based System (IAEA)
NPP	nuclear power plant
NRCan	Natural Resources Canada
NRU	National Research Universal
NSCA	*Nuclear Safety and Control Act*
NSCMP	Nuclear Safety Culture Monitoring Panel
NSRB	Nuclear Safety Review Board
OECD	Organisation for Economic Co-operation and Development
OP&P	operating policies and principles
OPEX	operating experience
OPG	Ontario Power Generation
OSCQ	Organisation de la sécurité civile du Québec
OSR	operational safety requirement
PAR	passive autocatalytic hydrogen recombiner
PLGS	Point Lepreau Generating Station
PMUNE	Plan des mesures d'urgence nucléaire externe
PNERP	Provincial Nuclear Emergency Response Plan
POC	Principles of Conduct
PSA	probabilistic safety assessment (same as probabilistic risk assessment (PRA))
PSR	periodic safety review
QA	quality assurance
R&D	research and development
reporting period	April 2010 to March 2013
RIDM	risk-informed decision making
RPD	Regulatory Program Division
RSI	Radiation Safety Institute
SAM	severe accident management
SAMG	severe accident management guideline
SOE	safe operating envelope
SSCs	structures, systems and components
TEPCO	Tokyo Electric Power Company
Type I inspection	All verification activities related to onsite audits and evaluations of licensee programs, processes and practices.
Type II inspection	All verification activities related to routine (item-by-item) checks and rounds.

UNENE	University Network of Excellence in Nuclear Engineering
UOIT	University of Ontario Institute of Technology
USA	United States of America
USNRC	United States Nuclear Regulatory Commission
WANO	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 as a Contracting Party to the Convention, as demonstrated in the Canadian reports presented at the review meetings of the Convention. Canada remains fully committed to the principles and implementation of the Convention.

During the Fifth Review Meeting of the Convention, the Contracting Parties in attendance agreed to hold an Extraordinary Meeting of the Convention in accordance with article 23 of the Convention "…to enhance safety through reviewing and sharing lessons learned and actions taken by Contracting Parties in response to events at Fukushima and to reviewing the effectiveness and, if necessary, the continued suitability of the provisions of the *Convention on Nuclear Safety*." This Second Extraordinary Meeting of the Convention was held at the headquarters of the International Atomic Energy Agency (IAEA) in Vienna from August 27 to 31, 2012. The officers of the Fifth Review Meeting continued as the officers for the Second Extraordinary Meeting. Canada prepared a report following the directions provided by the officers and participated in the review for the Second Extraordinary Meeting.

This report, which is for the Sixth Review Meeting, includes and updates, as appropriate, the information in Canada's reports for the Fifth Review Meeting and the Second Extraordinary Meeting.

This sixth 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, Natural Resources Canada, Health Canada, Public Safety Canada and the emergency response organizations of the provinces of New Brunswick, Ontario and Quebec.

A.1 Scope

As required by article 5 of the Convention, this sixth Canadian report demonstrates how Canada fulfilled its obligations under articles 6 to 19 of the Convention during the reporting period, which extended from April 2010 through March 2013. The report closely follows 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 sixth 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 fifth Canadian report. A particular focus is placed on the challenges identified for Canada at the Fifth Review Meeting and during the follow-up Integrated Regulatory Review Service (IRRS) mission. The report also focuses on Canada's responses to the lessons learned from Fukushima.

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 fourth *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 2011.

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 Fifth 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 do not directly apply to any particular article of the Convention, they represent the context within which the articles are met.

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

- progress on addressing the challenges identified for Canada at the Fifth Review Meeting
- progress on other important safety issues not covered by the challenges identified for Canada
- progress on the CNSC Action Plan implemented by the CNSC and the NPP licensees to address the lessons learned from Fukushima
- 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. The term "Contracting Party" in an article refers to each signatory to the Convention. For each article, the description of Canada's provisions to fulfill the relevant obligations is organized in 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 identified for Canada at the Fifth Review Meeting are highlighted in boxes near the beginning of the relevant discussion. Wherever applicable, the findings of other independent reviews, described briefly below, are also cited to corroborate or add insight to the information in this report.

In June 2009, Canada had hosted a mission by the IRRS (see article 8 for details). The findings from that initial mission were cited in the fifth Canadian report in order to provide complementary information from an independent review team regarding Canada's regulatory performance. In December 2011, Canada hosted a follow-up IRRS mission to evaluate the CNSC's responses to the findings from the initial IRRS mission in 2009, to evaluate areas that had not been evaluated in 2009 and to evaluate the CNSC's response to Fukushima (see article 8 for details). The findings from the follow-up IRRS mission in 2011 are also included in boxes in this report, along with the CNSC's responses to those findings.

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 or subsection to which the annex is relevant.

The full text of the first, second, third, fourth and fifth Canadian reports, the Canadian report to the Second Extraordinary Meeting and 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. This sixth Canadian report will be available on the CNSC Web site in late 2013 or early 2014, 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 Fifth Review Meeting

At the Fifth Review Meeting of the Convention, held in Vienna in April 2011, Canada was part of Country Group 5, which also included Germany, Bulgaria, Armenia, Austria, Peru, Nigeria, Greece, Ireland, the United Arab Emirates (UAE) and Switzerland. Canada presented its report at the Fifth Review Meeting to an audience of more than 90 participants, representing 18 countries. Canada also responded to comments and questions from numerous country delegations, including Ireland, the UAE, India, Argentina, China, Romania, Belgium, Korea, the United States, Pakistan, Germany, Switzerland, the United Kingdom and France. These comments and questions pertained to such topics as CNSC independence and transparency, training, refurbishment, new reactors, recruitment and retention strategies, risk-informed decision-making, new licence format, the CNSC compliance program, safety culture, dose limits, probabilistic safety assessment, large-break loss-of-coolant accidents (LBLOCAs), regulatory framework, severe accident management guidelines (SAMGs) and emergency preparedness.

The following table lists the challenges identified for Canada at the Fifth Review Meeting, as recorded in the Rapporteur's Summary Report for Country Group 5. Cross-references to the relevant subsections of this sixth Canadian report are also provided.

Challenges for Canada from the Fifth Review Meeting

#	Text of challenge	Relevant subsection
C-1	Continue implementation of PSR (periodic safety review)	14(i)(h)
C-2	Overcome the effects of potential human resource shortages in the energy sector arising from refurbishment and new constructions	8.1(c), 11.2
C-3	Complete implementation of severe accident management guidelines (SAMGs)	19(iv)

C. National nuclear framework and policy

C.1 General framework

In Canada, the development and implementation of nuclear energy policy fall within federal jurisdiction. The Government of Canada has funded nuclear research and has supported the development and 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 nuclear research and development (R&D) activities primarily through Atomic Energy of Canada Limited's (AECL) nuclear laboratories. The nuclear industry provides, via the R&D program of the CANDU Owners Group (COG; described in subsection D.1), approximately $40 million annually for research that supports operating NPPs. Other joint programs that are arranged through COG contribute another $15 to $20 million annually to R&D that supports NPPs in Canada. The national nuclear research program is summarized in appendix E.

Although the Government of Canada has important responsibilities related to nuclear energy, the decision to invest in electricity generation rests with each province. It is up to 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 sector 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 percent of Canada's electricity.
- In the province of Ontario, approximately 53 percent of electricity production is from NPPs.
- Canada's nuclear technology sector has enabled healthcare providers to improve cancer therapy and diagnostic techniques (Canada is a major supplier to the world market for medical isotopes).
- Canadian Deuterium Uranium (CANDU) reactors have been built and operated in several countries: currently, four in operation in South Korea, two in China, two in 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, directly employing more than 30,000 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

Under Canada's constitution, responsibility for nuclear energy falls within the jurisdiction of the federal government. Its role encompasses R&D, 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 implemented by Canada's independent nuclear regulator – the Canadian Nuclear Safety Commission (CNSC).

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

- Natural Resources Canada (NRCan), which establishes policies, priorities and programs for energy science and technology; administers the *Nuclear Energy Act*, the *Nuclear Liability Act* and the *Nuclear Fuel Waste Act;* has overall responsibility for managing historic nuclear wastes; and is responsible for the *Nuclear Safety and Control Act* (NSCA), which is administered by the CNSC
- Public Safety Canada, which is the lead authority for the Federal Emergency Response Plan
- Health Canada, which establishes radiological protection standards and monitors occupational radiological exposures and is also responsible for the Federal Nuclear Emergency Plan
- Transport Canada, which develops and administers policies and regulations for the Canadian transportation system, including the transportation of dangerous goods
- Environment Canada, which contributes to sustainable development through pollution prevention, in order 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 recently updated *Canadian Environmental Assessment Act, 2012* (CEAA 2012), which delegates responsibility for conducting environmental assessment (EA) reviews of proposed nuclear projects under the NSCA to the CNSC
- Department of Foreign Affairs and International Trade (DFAIT), which establishes and administers the nuclear non-proliferation policy and export controls implemented by the CNSC

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

The memorandum of understanding between the CNSC and Health Canada was updated during the reporting period and signed in 2012. The memorandum ensures that comprehensive and consistent regulatory oversight of radiation safety with respect to patient safety is in place. In particular, it formalizes the roles and responsibilities of the Federal Provincial Territorial Radiation Protection Committee.

The NSCA, the *Nuclear Energy Act*, the *Nuclear Fuel Waste Act* and the *Nuclear Liability Act* are the centrepieces of Canada's legislative and regulatory framework for nuclear matters. The NSCA is the key piece of legislation for ensuring the safety of the nuclear industry in Canada. Other legislation that provides emergency management, environmental protection and worker protection, such as the *Emergency Management Act*, the *Canadian Environmental Assessment Act* (CEAA), the *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, support for CANDU technology, and co-operation with provincial governments and municipal jurisdictions.

Atomic Energy of Canada Limited (AECL) is a Crown corporation of the Government of Canada that reports to the Parliament through the Minister of NRCan. AECL is a strategic element of both Canada's national science and technology infrastructure and its national innovation system. AECL is Canada's premier nuclear science and technology organization – its unique capabilities include the ability to work with nuclear and radioactive materials. These capabilities are applied in fields important to public policy and to the nuclear sector domestically and internationally. AECL also acts as an advisor to and agent of the Government of Canada for public policy purposes, especially in the field of nuclear safety.

Canada has excellent working relationships with the United States for the exchange of nuclear regulatory and emergency preparedness expertise.

Canada is actively involved in IAEA-sponsored activities, including the IAEA Nuclear Safety Action Plan, and fully supports the IRRS program and its missions.

Canada is actively involved with a number of other international organizations, including the International Nuclear Regulators Association, the CANDU Senior Regulators group, the Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development (OECD) and the 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. The CNSC chairs the CANDU Senior Regulators' Meeting and uses this forum to share regulatory information that is specifically relevant to CANDU NPPs. For example, the CNSC distributed its report on Category 3 CANDU safety issues (see subsection 14(i)(g) for an explanation) with other CANDU Senior Regulators. Canada is also a participant in the International Framework for Nuclear Energy Cooperation, the Multinational Design Evaluation Programme (MDEP; see article 18) and the Generation IV International Forum, and has established a national Generation IV program (see appendix E).

Canada has signed and ratified five other multilateral conventions on nuclear safety:

- The *Joint Convention on 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*
- The *Convention on Early Notification of a Nuclear Accident* (see subsection 16.2(b) for details)
- The *Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency* (see subsection 16.2(b) for details)

C.3 Overall federal response to Fukushima

Immediately after the incident at Fukushima, the CNSC:

- activated the CNSC Emergency Operations Centre and staffed it 24/7 to monitor the emergency, assess early reports and provide timely, accurate information to Canadians (see subsection 16.1(d) for details)
- performed inspections and walkdowns at nuclear facilities to assess the readiness of mitigating systems (see subsection 7.2(iii)(b) for details)

- requested Canadian licensees of Class I nuclear facilities and uranium mines and mills to review the lessons learned and re-examine the safety cases of the facilities, in particular the underlying defence-in-depth concept (see subsection 8.1)
- convened the CNSC Fukushima Task Force to evaluate the operational, technical and regulatory implications of the accident for NPPs in Canada (see subsection 8.1)

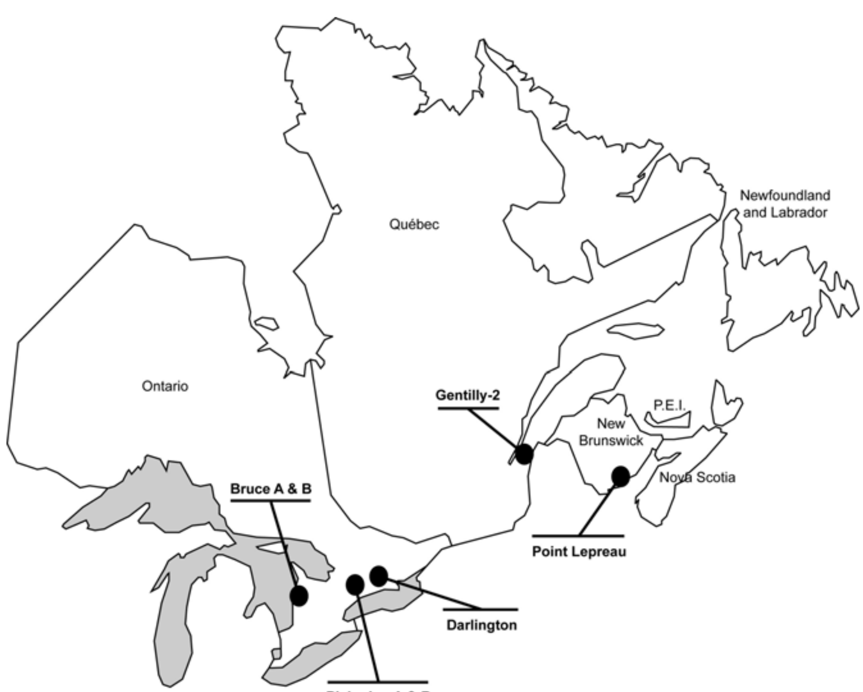
Other federal organizations, including DFAIT, Health Canada/Public Health Agency of Canada, and Public Safety Canada, also activated their emergency operations centres to coordinate the federal response to the emergency.

Federal organizations, including the CNSC's nuclear emergency organization, Health Canada's Radiation Protection Bureau, Public Health Agency of Canada and Environment Canada–Canadian Meteorological Centre, supported the Canadian DFAIT Japan Crisis Team on a daily basis by providing timely and accurate information to Canadians in Japan, particularly advising the Canadian ambassador and his staff in Japan. Information was posted on the Web sites of the CNSC, DFAIT, Health Canada and Public Health Agency of Canada to provide consistent, objective and credible source of information for the Canadian public, CNSC staff and other government departments. Coordinated efforts were also undertaken to monitor the Canadian environment and address issues of public concern.

D. Nuclear power industry and recent major activities

D.1 Nuclear power industry in Canada

Of the 22 nuclear power reactor units in Canada, 19 are currently producing power. Their locations within Canada are shown in the partial map below. During the reporting period, three reactor units completed refurbishment activities (Bruce A Units 1 and 2 and Point Lepreau). In addition, two units at Pickering A were in a safe storage state and one unit (Gentilly-2) started the process toward permanent shutdown and decommissioning (see description below). The operation of these reactors was governed by seven operating licences.



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

Immediately after the incident at Fukushima, each NPP licensee commenced a thorough review of the lessons learned from Fukushima and, during the reporting period, completed or initiated various improvements to address these lessons learned.

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

Licensee and number of reactors at each NPP site

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	Quebec	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 (originally developed by AECL). Besides Canada, there are six other countries with CANDUs in operation. A full description of CANDU reactors was provided in the first and second Canadian reports.

The Government of Canada took steps to strengthen Canada's nuclear industry by restructuring AECL. In October 2011, the Government completed the sale of the assets of AECL's CANDU reactor division to Candu Energy Inc., which is a wholly owned subsidiary of SNC-Lavalin Inc. Candu Energy is a full-service, nuclear technology company that provides nuclear power reactors and nuclear products and services to customers worldwide. Candu Energy acts as the original designer and vendor of the CANDU technology. Candu Energy has four reactor designs:

- CANDU 6: The current fleet of reactors in operations is based on the existing CANDU 6 design, a heavy-water moderated reactor utilizing natural uranium fuel and on-power refueling
- Enhanced CANDU 6: A Generation III, 700 MWe class heavy-water moderated and cooled reactor that is based on the successful CANDU 6 model
- Advanced CANDU Reactor (ACR-1000): An evolutionary, Generation III+, 1,200 MWe class heavy water reactor
- Advanced Fuel CANDU Reactor: Designed to use alternative fuels such as recovered uranium from the reprocessing of used light-water reactor fuel, low-enriched uranium and plutonium-mixed oxide and thorium, in addition to the conventional natural uranium.

Candu Energy is currently working with China to further develop thorium as an alternative fuel source.

Candu Energy was a key industry participant in the response to Fukushima. In addition to reactor design, Candu Energy also provides services for existing CANDU NPPs in the following areas:

- life extension projects
- plant life management programs and tools
- operation and maintenance

AECL remains a federal Crown corporation with more than 3,200 employees. It is a strategic part of Canada’s national science and technology infrastructure and national innovation system. AECL is the knowledge leader of the Canadian nuclear industry and operator of unique facilities that, together, foster excellence and advancement in nuclear science and technology.

In February 2012, the Government of Canada launched the second phase of its AECL restructuring plan, issuing a request for expression of interest to understand potential opportunities for partnership models in relation to the nuclear laboratories and to help inform the restructuring process. In February 2013, the Government of Canada announced that it would proceed with a competitive procurement process to select a contractor to manage and operate AECL’s nuclear laboratories, while ownership would be maintained by the government. The nuclear laboratories will focus on three key objectives:

- managing their radioactive waste and decommissioning responsibilities
- performing science- and technology-related activities to meet core federal responsibilities
- supporting Canada’s nuclear industry through access to science and technology facilities and expertise on a commercial basis

Noting that the end of the design life of Gentilly-2 was approaching during the previous reporting period, the fifth Canadian report described the preference of Hydro-Québec to refurbish Gentilly-2, thus extending the life of that unit until the 2040 time frame, instead of shutting it down. However, in September 2012, the government of the Province of Quebec decided, based on economic considerations, to close the NPP rather than refurbish it. A team was established to plan and execute the shutdown and decommissioning activities. In December 2012, the unit was shut down in the same manner as for an annual maintenance outage, and the work to place the unit in a safe shutdown state commenced. The first steps included defuelling and maintenance of systems important for ongoing safety. During the next reporting period, Hydro-Québec will focus on deactivating and draining key systems, storing heavy water, confining radioactive sources and continuing the surveillance and maintenance necessary to ensure the safety of the spent fuel and manage other potential hazards.

Hydro-Québec foresees having all fuel in dry storage by 2055 and dismantling the plant in the 2055–60 time frame, followed by the restoration of the site.

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 co-operation, 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. Membership is restricted to organizations owning or operating a CANDU nuclear reactor, but supplier and engineering organizations involved in the design, construction and operation of CANDU reactors are eligible for participation in specific programs. COG is described further in subsection 9(d).

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, along with 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 each life extension project is briefly described below (see subsection 14(i)(g) for details).

Refurbishment of Bruce A

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

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

Unit 2 achieved criticality in March 2012 but a problem with the generator prevented first synchronization to the power grid until October 2012. Unit 1 achieved criticality in July 2012 and synchronized to the grid in September 2012. Both units were declared in commercial service in October 2012.

Bruce Power has not yet committed to the refurbishment of Units 3 and 4 or to the refurbishment of its units at Bruce B.

Pickering A and B

Pickering A, which encompasses Units 1 through 4, came into service in 1971. Following refurbishment activities, Unit 1 and Unit 4 were returned to service in 2005 and 2003, respectively. In 2005, OPG decided not to return Units 2 and 3 to service, based on an economic evaluation. In 2010, Units 2 and 3 were each placed in a safe storage condition, which involved removing the fuel and heavy water from the reactors, isolating these units from the operational part of the station (such as containment) and placing the units in a state that prevents re-energization. Some Unit 2 and 3 systems remain energized, providing common system support to the operation of Units 1 and 4. Units 2 and 3 will be maintained in safe storage states until the entire NPP is shut down for eventual decommissioning. Pickering Units 1 and 4 will be shut down coincident with the final two Pickering B units.

Pickering B, which encompasses Units 5 through 8, came into service in 1983. An extensive integrated safety review (ISR) was completed in 2010 to assess the options for its ongoing service. Near the end of the previous reporting period, OPG decided that incremental life extension, rather than the options of shutdown or refurbishment, was the best option. The decision to not refurbish was based on economic factors, such as the capacity of the units, rather than on safety concerns.

In 2010, OPG developed a continued operations plan to document the technical basis actions required to support the incremental life extension of the Pickering B units to the end of 2020. The plan integrates the improvements necessary to close issues identified in the EA and ISR for Pickering B during the previous reporting period. The continued operations plan is updated annually. The life-limiting components of Pickering B units are the pressure tubes, which will reach the end of their assumed design lives in approximately 2015. Significant progress has been made in completing these actions. In 2012, the most notable action completed was the analysis to support the extension of the effective lives of the Pickering B fuel channels: this is a major milestone for providing the technical basis to continue operation to 2020. See subsection 14(i)(c) for further details.

In 2011, OPG developed a sustainable operations plan for Pickering A and B that contains strategic plans recognizing the unique challenges associated with the approach to the end of commercial operation. The sustainable operations plan, which is also updated annually, describes the arrangements and activities required to demonstrate that safe and reliable operation of Pickering will be maintained and sustained, for each of the 14 CNSC safety and control areas, for the period of operation until each reactor unit is permanently shut down.

Pickering A's Units 1 and 4 Pickering B's Units 5 through 8 will continue to operate until the entire NPP is permanently shut down.

The current plan is to shut down all units at Pickering by the end of 2020.

Refurbishment of Darlington

The four reactors at Darlington came into service from the late 1980s to the early 1990s. During the reporting period, OPG completed an ISR and EA for Darlington refurbishment and continued operation. In March 2013, the tribunal component of the CNSC (hereinafter referred to as "the Commission") announced its positive decision on the EA, concluding that the proposed project is not likely to cause significant adverse environmental effects, taking into account mitigation measures identified in the EA. At the end of the reporting period, OPG was continuing its global assessment and integrated improvement plan to specify the scope of the refurbishment. The refurbishment of the first unit is expected to start as early as 2016. The units could be refurbished one at a time and all would be expected to return to service by approximately 2025.

Refurbishment of Point Lepreau

Point Lepreau came into service in 1982. The refurbishment outage started in March 2008. During the previous reporting period, various activities to retube the unit and upgrade safety were undertaken – these are described in detail in the fifth Canadian report. Remaining refurbishment activities were completed during the reporting period. Following extensive commissioning activities, the unit was returned to service and declared in commercial operation in November 2012.

D.3 New-build projects

As described in the fourth Canadian Report, in 2006 OPG submitted an application for a licence to prepare a site for future construction of NPPs within the existing boundary of the Darlington site. The project aims to site up to four new nuclear reactors, with a maximum of 4,800 megawatts of electrical output (MWe), directly east of the existing Darlington site in the municipality of Clarington, Ontario. As described in the fifth Canadian report, in 2009 OPG submitted its EA, as well as the remaining licensing submissions, in support of the application for a licence to prepare the site.

Following a public review process and a public hearing, the Joint Review Panel appointed to conduct the EA provided its EA report to the Government of Canada in August 2011. The panel concluded the project is not likely to cause significant adverse environmental effects, provided the mitigation measures proposed and commitments made by OPG during the review, along with the panel's recommendations, were implemented. Following the Government of Canada's approval of the EA, in August 2012, the Joint Review Panel (as a panel of the Commission) issued OPG a licence to prepare the site. More details on this application are provided in article 17 and annex 17.

The OPG site preparation activities will occur following selection of a vendor by the Province of Ontario.

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 the safety performances of their NPPs. The Canadian NPP licensees fulfill their responsibilities to safety, giving it the highest priority at all levels of their organizations. Many provisions are in place 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, striving to continuously improve it.

Overall safety performance

Canada has a mature nuclear industry, with an excellent safety record spanning several decades. Any safety issues that arise are addressed by licensees, in order to keep risk at their NPPs at reasonable levels. Canadian NPP licensees also collaborate on many projects to address safety issues and share information. For example, the NPP licensees collaborated with AECL through COG to align severe accident management assessments and methodology for implementing actions in response to Fukushima.

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. 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 percent of the derived release limits. The licensees' safety analyses, as described in the safety analysis reports, demonstrated adequate safety margins for all Canadian

NPPs. The level of defence in depth also remained adequate during the reporting period for all operating NPPs.

Regulatory framework improvements

The CNSC's regulatory framework and processes feature a high degree of openness and transparency. The CNSC continued to enhance openness and transparency during the reporting period. For example, the CNSC established a participant funding program to facilitate the participation of eligible intervenors in the decision-making process. The CNSC also continued its effective use of discussion papers to solicit early public feedback on potential regulatory changes.

During the reporting period, the CNSC continued its progress in enhancing the regulatory framework – which included various regulatory documents relevant to NPPs (both existing NPPs and new-build projects) – along with progress in aligning the regulatory framework with international standards (as a minimum). These changes have been introduced into the regulatory framework in a risk-informed way. Renewals of operating licences for NPPs (approximately every five years) have been used to introduce new standards and requirements, with provisions for implementation of the new requirements over predefined time periods. Typically, the Canadian approach to the setting of requirements is non-prescriptive; that is, the CNSC sets general, objective, performance-based regulatory requirements and NPP licensees develop specific provisions to meet the requirements. Specific requirements can be established where necessary. Provisions critical to safety are approved by the CNSC before licensed activity can begin.

During the reporting period, the CNSC also continued its licence reform project and development of licence condition handbooks (LCHs). All existing NPPs now have streamlined licences to operate that enhance consistency and regulatory efficiency. All NPPs also have LCHs, which state the compliance verification criteria that CNSC staff will use to judge regulatory compliance and provide additional guidance on how to achieve compliance.

The CNSC has continued to enhance the compliance program for operating NPPs, including the development of inspection guides, in addition to continuing its development of compliance program elements required to oversee the various new-build licensing stages, optimize its employment levels and identify organizational requirements, staffing complements and skill sets for inspectors to implement the compliance program. The CNSC continued to participate in the Major Projects Management Office and the Multinational Design Evaluation Programme (MDEP) and continued its vendor pre-project design reviews.

The CNSC has a comprehensive program to assure compliance with the regulatory framework and monitor the safety performance of the NPPs. A comprehensive set of graduated enforcement tools are available to the CNSC to address non-compliances. An additional tool was introduced during the reporting period – administrative monetary penalties (AMPs) – that will enhance the CNSC's effectiveness and flexibility in enforcement.

Assessments and peer reviews

A follow-up IRRS mission to Canada was completed in December 2011. The assessment covered three distinct areas:

- follow-up on findings from the initial IRRS mission to Canada in 2009

- regulatory implications of Fukushima
- regulation of the transport of radioactive material

The follow-up mission report noted the following strengths:

- The recommendations and suggestions from the initial IRRS mission in 2009 were systematically addressed through active senior management commitment.
- The regulatory response to the Fukushima accident was prompt, robust and comprehensive.
- The regulatory framework for transport of radioactive materials is well established and commensurate with the large scope and volume of transport activities in Canada.

In terms of the follow-up part of the assessment, the peer-review team concluded that 13 of 14 recommendations and 17 of 18 suggestions made during the initial IRRS mission had been effectively addressed and therefore could be considered closed. The one IRRS recommendation from 2009 that remained open, that of implementing periodic safety review (PSR), is being systematically addressed (discussed below). The one IRRS suggestion from 2009 that remained open is not directly relevant to NPPs. The Fukushima component of the assessment in 2011 identified one good practice, two recommendations and one suggestion for follow-up. The good practice cited the CNSC's thorough review of lessons learned from Fukushima and its action plan that systematically addressed all the recommendations that resulted from the CNSC's review. The recommendations and suggestion were all related to emergency preparedness and are being systematically addressed.

The CNSC ratings of NPP safety performance under the CNSC safety and control areas confirmed that CNSC requirements and performance expectations in all safety and control areas were met or exceeded at the NPPs for the reporting period, with only a very small number of exceptions back in 2010. In those few safety and control areas where CNSC expectations were not met, the licensees implemented corrective action plans. The integrated plant ratings were either fully satisfactory or satisfactory for all NPPs in 2010, 2011 and 2012.

Other reviews, findings and responses are discussed below in the context of the response to Fukushima.

Life extension, continued operation and associated safety improvements

NPP life extension projects, implemented for extending the safe operating lives of NPPs well beyond their initial design lives, continued and terminated during the reporting period at Bruce A and Point Lepreau. Condition assessments, integrated safety reviews (ISRs) and integrated implementation plans were part of a systematic approach to not only maintain the levels of safety of the refurbished NPPs but to improve them relative to the pre-refurbished condition. The reviews were conducted against modern standards and practices and all practicable improvements were considered and implemented. In addition to the replacement of major reactor components such as fuel channels, feeders and steam generators, these life extension projects implemented other safety improvements such as the following:

- addition of reactor trips or set points
- installation of passive autocatalytic hydrogen recombiners (PARs)
- installation of a third Class III electrical power standby diesel generator at Point Lepreau
- installation of a secondary control area at Bruce A

A fuel channel life management project has been used by OPG and Bruce Power, along with AECL, to identify and manage the specific degradation mechanisms for fuel channels, which are the components that typically limit the safe operating life of CANDU reactors. The results of the fuel channel lifecycle management project, which includes operational experience through inspection and extensive research, have been used to better justify the continued operation of existing NPPs that are approaching the end of their analyzed safe operating lives.

Addressing the challenges for Canada from the Fifth Review Meeting

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

Challenge C-1: Continue implementation of PSR

During the reporting period, Canada continued to evaluate the implications of formally incorporating PSR into the Canadian regulatory process for NPP licensing, taking into account the lessons learned through the application of ISR to NPP refurbishment projects. It was concluded that, in addition to periodic licence renewal, adopting the PSR methodology would result in some benefits for regulatory oversight of NPPs. The CNSC Fukushima Task Force also considered that PSR should be integrated into the NPP licensing process, e.g., on a 10-year cycle, with the results becoming part of the licensing basis for the NPP. The CNSC is planning to update its regulatory document *Life Extension of Nuclear Power Plants* (RD-360), which includes requirements for ISRs. The revision will stipulate the periodic performance of the comprehensive ISR process in conjunction with licence renewal. Recognizing the value of PSR, OPG and Bruce Power have committed to the implementation of a PSR process in support of long-term operation of Darlington and Bruce A and B, with the first full PSR submissions planned for 2014 and 2019, respectively.

Challenge C-2: Overcome potential human resource shortages related to refurbishment and new-build projects

The NPP industry has extensive and effective programs related to training, staffing, examination, workforce capacity evaluation, hiring, knowledge retention and research and development. At the same time, the demand for human resources decreased during the reporting period (e.g., due to decisions to close Gentilly-2 and not refurbish Pickering B, as well as a longer-than-anticipated time frame for the Province of Ontario to decide to proceed to the new-build construction phase). Consequently, the potential human resource shortage identified at the Fifth Review Meeting is being addressed.

Challenge C-3: Complete implementation of severe accident management guidelines

Severe accident management guidelines (SAMGs) have been implemented at all operating NPPs. In the case of Gentilly-2, Hydro-Québec is developing a specific program for the irradiated fuel bay while the NPP proceeds towards decommissioning. During the reporting period, the NPP licensees enhanced training programs to clarify roles and test SAMG effectiveness and also conducted validation drills. SAMGs are being incorporated into existing emergency plans.

The review of lessons learned from Fukushima concluded that SAMGs were generally adequate, but three specific actions were identified for follow-up:

1. Develop/finalize and fully implement SAMGs at each NPP.
2. Expand the scope of SAMGs to include multi-unit and irradiated fuel bay events (see the Canadian report for the Second Extraordinary Meeting for details).
3. Validate and/or refine SAMGs to demonstrate their adequacy to address lessons learned from Fukushima.

Some licensees have completed the implementation and validation of SAMGs. Plans to address the additional enhancements to SAMGs are being developed.

Response to Fukushima

The CNSC took a systematic approach in response to Fukushima. It made formal requests to the NPP licensees for information and assessments that confirmed the safety case for each NPP and addressed lessons learned from Fukushima. The CNSC established a task force and criteria to assess the lessons learned, the submissions from licensees and also its own regulatory framework. The CNSC developed its *CNSC Integrated Action Plan: On the Lessons Learned From the Fukushima Daiichi Nuclear Accident* (the CNSC Action Plan for short), with short-, medium- and long-term actions assigned to both licensees and the CNSC itself, in all key areas – encompassing defence in depth, emergency preparedness, regulatory framework and processes and international co-operation. The CNSC also appointed an External Advisory Committee (EAC) of independent experts to assess the organization's processes and responses in light of the Fukushima lessons learned.

The licensees responded to the CNSC's request in a timely manner and have completed, or are carrying out, numerous assessments, analyses and design improvements. All short-term actions from the CNSC Action Plan have been completed and closed.

Licensees performed reviews and upgrades to the design and operations of their facilities and to the emergency response in case of severe accidents. The following lists, for illustration purposes, a few of the many examples:

- Assessments were performed to demonstrate the confidence in the current design.
- New equipment was installed or procured and designs were upgraded to improve defence in depth (e.g., passive autocatalytic hydrogen recombiners, instrumentation and control power supply, additional flood protection at Darlington and Pickering).
- Emergency plans were reviewed and upgraded at all the facilities (with the exception of Gentilly-2) with the acquisition of emergency mitigating equipment and backup power, with the development of SAMGs and with the formalization of agreements between the operators and the external emergency response organizations.
- Real-time, near-boundary radiation monitoring was planned or completed and source term estimation capability was reviewed by NBPN.

The remaining actions are ongoing and will be completed during the next reporting period.

The CNSC also addressed various actions in the CNSC Action Plan and responded to the recommendations of the EAC, including initiation of amendments to the *Radiation Protection Regulations* and the *Class I Nuclear Facilities Regulations* to enhance requirements related to doses for emergency workers and to offsite emergency preparedness. The CNSC worked to enhance and update the requirements and guidance in several CNSC regulatory documents based on lessons learned. The CNSC also engaged other national organizations to help coordinate improvements to various provisions, such as for emergency preparedness.

Summary of other safety improvements during the reporting period

In addition to addressing the three challenges from the Fifth Review Meeting and initiating numerous safety improvements in response to Fukushima, 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:

- completion of life extension activities at Bruce A Units 1 and 2 and Point Lepreau, including replacement of key reactor pressure-retaining components, such as fuel channels, feeders, steam generators and condensers, as well as numerous other improvements, such as the construction of a secondary control area
- enhancements to alpha protection programs at all NPPs
- fire protection system upgrades at various NPPs
- concurrence that two of the CANDU safety issues can be downgraded from Category 3 to Category 2 (i.e., it was concluded that measures are in place to manage these two issues and maintain existing safety margins)

Summary of planned activities to improve safety

The CNSC and NPP licensees plan to continue the initiatives and safety improvements described above and to undertake other safety improvements and modifications that address conditions during beyond-design-basis accidents. All items in the CNSC Action Plan are expected to be completed by 2015. Other planned improvements during the next reporting period include the following:

- preparations for life extension of Darlington
- resolution of CANDU safety issues, supported by analysis and testing
- ongoing improvements to deterministic safety analysis
- completion of full-scope probabilistic safety assessment (PSAs) at all operating NPPs
- execution of enhanced fuel channel lifecycle management
- preparations for PSR
- conduct of a full-scale, national emergency exercise at an NPP involving all levels of government and other institutions

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 sites, each with its own operating licence issued by the CNSC. Appendix B provides basic information on all the units at the Canadian nuclear power plants (NPPs).

6 (b) Justification of continued operation of Canadian NPPs

General safety framework and overall description of safety evaluations

Activities related to NPPs in Canada are governed by robust, modern legislation, with appropriate and well-defined powers to ensure 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. The CNSC continues to update its regulatory framework and align it with international standards (as a minimum). 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. 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 responsibilities to safety, giving 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 it. This is evidenced by a willingness to engage in third-party evaluations, such as by the IAEA’s Integrated Regulatory Review Service (IRRS) and the World Association of Nuclear Operators (WANO). The involvement of third-party expertise and the participation in international fora and activities, such as the development of IAEA standards, strengthen these provisions.

The safety of all existing NPPs in Canada was fully reviewed for their initial licensing. Both the licensees and the CNSC 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 (OPEX). The licensees and the CNSC have also conducted many detailed verification activities in support of ongoing operations. The licensees limit the life of critical components (such as CANDU fuel channels) and implement aging management plans to help ensure ongoing safe operation. The licensees 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 and manage aging mechanisms on a continual basis.

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

NPP licensees have conducted integrated safety reviews (ISRs), which are similar in scope to periodic safety reviews (PSRs), 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 – all robust mechanisms for the safe extension of the operating lives of NPPs. These activities have helped enhance the level of safety of refurbished NPPs as compared to the pre-refurbished conditions. ISRs are described in subsection 14(i)(g).

NPPs have reassessed their safety cases through regular safety analysis report updates but also as part of follow-ups of environmental assessments (EAs) or as reviews of lessons learned in the context of special circumstances like that of Fukushima.

Response to Fukushima

Canada conducted a through review of the lessons learned from Fukushima and actively applied them to improve the safety of NPPs; see article 8 and subsection 9(b) for a basic description of the responses to Fukushima by the CNSC and NPP licensees. No issues were identified that called into question the safety cases of existing NPPs; however, various opportunities were identified to strengthen the NPPs against severe external events and beyond-design-basis accidents. The NPP licensees have systematically addressed the identified issues and completed or committed to implement safety improvements in a timely manner. The CNSC guided the licensees through the process and evaluated their assessments and proposals while assessing its own regulatory framework. In addition, the CNSC is pursuing various initiatives to strengthen the regulatory framework.

Operational safety record

Canada has a mature nuclear industry with an excellent safety record spanning several decades. None of the operational events that occurred at Canadian NPPs during the reporting period posed a significant threat to the health and safety of persons or to the environment. There were no serious process failures at any NPP during the reporting period. The licensees' efforts to address operational 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 such as 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 a 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. This framework consists of laws (acts) passed by the Parliament of Canada that govern the regulation of Canada's nuclear industry and regulatory instruments such as regulations, licences, orders and documents that the CNSC uses to regulate the industry.

The *Nuclear Safety and Control Act* (NSCA) is the enabling legislation for the regulatory framework. 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. CNSC regulatory documents, as well as other standards, also become legally binding requirements once they are referenced in licences: they become part of the licensing basis, as defined in subsection 7.2(ii)(a). The NSCA, regulations, regulatory documents, licences and orders are described in more detail in the subsections below.

The report of the initial IRRS mission in 2009 stated, as a particular strength of Canada:

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

The Canadian nuclear legislative and regulatory framework was reviewed by the CNSC Fukushima Task Force. The Task Force (described in article 8) examined all the elements and found no need to revisit the structure of the regulatory framework as a result of the lessons learned from Fukushima. The Task Force concluded that the Canadian regulatory framework is strong and comprehensive and is effectively applied, even for severe accidents. The Task Force also reviewed the CNSC's key regulatory processes (e.g., relating to licensing, compliance and maintaining and enhancing the regulatory framework) – see the relevant subsections below for its conclusions.

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, along with the issuing of licences provide for the involvement of interested parties and timely communications to stakeholders (subsection 8.1(f) provides additional information on the CNSC's communications, openness and transparency).

During the reporting period, the CNSC continued to modernize its regulatory framework and library of regulatory documents, taking into consideration opportunities to improve the cataloguing and clarity of the regulatory framework. All activities were carried out with a continued focus on communicating and engaging with stakeholders, including the continued use of "discussion papers", which play important roles in the selection and development of the regulatory framework and regulatory program. Discussion papers are used to solicit early public feedback on CNSC policies or approaches, which the CNSC then analyzes and considers in order to help determine the type and nature of requirements and guidance to issue. The use of discussion papers early in the regulatory process underlines the CNSC's commitment to a transparent consultation process, giving stakeholders an early opportunity to present their positions on regulatory initiatives.

Upon posting a discussion paper on the CNSC's Web site, the CNSC notifies stakeholders via a bulletin, its Facebook page and the Government of Canada's "Consulting with Canadians" Web site. The CNSC invites feedback during a specified period, posts the comments it receives on its Web site and invites further feedback on the initial comments received. The CNSC takes all feedback received into consideration in determining its regulatory approach. Finally, the CNSC publishes a summary of all input received.

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 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 comprises two components: the tribunal component of the CNSC (hereinafter referred to as "the Commission") and a staff organization The Commission is an independent, quasi-judicial administrative tribunal consisting of up to seven Commission members appointed by the Canadian federal government for terms of up to five years (renewable). The competency profile for Commission members requires they each have a significant scientific, engineering and/or business background. They are not necessarily nuclear specialists, but bring strong reputations and transferable skills to Commission proceedings. The independence of the Commission is described in subsection 8.2(a). The Commission 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 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
- the certification of persons requiring certain qualifications to carry out duties under the NSCA

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

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
- provision for the Commission to redetermine 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

The CNSC is also responsible for administering and implementing Canada's international obligations pursuant to existing bilateral and multilateral nuclear co-operation agreements, conventions and undertakings, including nuclear safeguards and the import and export of controlled nuclear equipment, material and information.

The NSCA was amended in 2010 to enable the CNSC to establish a participant funding program, described in subsection 8.1(f).

The CNSC Fukushima Task Force reviewed the NSCA as part of its overall review of the regulatory framework. The Task Force found that the NSCA is sound and does not need revision as a result of any lessons learned from Fukushima.

In June 2012, as part of the Government of Canada's Responsible Resource Development initiative, Parliament amended the NSCA to authorize the CNSC to implement a new enforcement tool to address violations – the administrative monetary penalty (AMP). AMPs are intended to strengthen environmental protection and to increase compliance with the NSCA and its associated regulations. The CNSC is developing regulations to implement AMPs. See subsections 7.2(i)(a) and 7.2(iv) for details.

7.1 (b) Other legislation, conventions or legal instruments

Nuclear regulation is 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 facilities and activities and that do not conflict with federal law. Where both federal and provincial laws may apply, the CNSC tries to avoid duplicate effort by seeking co-operative arrangements with federal and provincial bodies that have regulatory responsibilities or expertise in these areas. Such arrangements are authorized by the NSCA, in order to avoid regulatory overlap. For example, 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*. As another example, provincial environmental legislation applies to nuclear facilities and the CNSC also shares the federal regulation of environmental protection with Environment Canada, in accordance with the *Canadian Environmental Protection Act*.

The following 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 *Radiation Emitting Devices Act*
- the *Canadian Environmental Assessment Act* (CEAA)
- the *Canadian Environmental Protection Act*
- the *Canada Labour Code*
- 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*

The Canadian Parliament amended the CEAA in 2012; the specific aspects of the CEAA that impact nuclear projects are detailed in subsections 7.2(ii)(a) and 17(ii)(a).

7.2 Provisions of the legislative and regulatory framework

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

7.2 (i) National safety requirements and regulations

During the reporting period, the CNSC developed and implemented a comprehensive, long-term plan to further develop and enhance the set of regulatory instruments in order to meet the ongoing needs of the CNSC and all its stakeholders.

Suggestion S14 from initial IRRS mission in 2009

"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."

During the reporting period, the CNSC reviewed its regulations, information documents, regulatory documents and guidance documents. The CNSC updated its regulatory framework plan for the years 2012 to 2018 to outline the regulations and regulatory documents it will be developing or amending. This long-term plan allows for more effective long-term planning of resources and better scheduling of projects within the regulatory framework. The peer-review team for the follow-up IRRS mission in 2011 concurred that the CNSC has developed a plan for systematic review of published regulations and regulatory guidance. On that basis, it closed suggestion S14.

7.2 (i) (a) Regulations under the NSCA

Under the NSCA, the CNSC has implemented regulations and by-laws with the approval of the governor in council. Regulations set information requirements for all types of licence applications and obligations and provide for exemptions from licensing. By-laws are in place to govern the management and conduct of the CNSC's affairs.

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

- *General Nuclear Safety and Control Regulations*
- *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*
- *Canadian Nuclear Safety Commission By-laws*

The CNSC's regulatory regime defines NPPs as Class IA nuclear facilities and the regulatory requirements for these facilities are found in the CNSC's *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 instead set out rules of procedure for public hearings held by the Commission and for certain proceedings conducted by officers designated by the Commission.

Generally, these regulations give licensees flexibility in how to comply with legislative requirements. With some exceptions — such as the transport packaging and licence exemption criteria for certain devices — the regulations do not specify detailed criteria used in assessing licence applications or judging compliance.

In January 2013, as part of the Government of Canada's Responsible Resource Development initiative, the CNSC, with approval from the governor in council, amended the *Class I Nuclear Facilities* and *Uranium Mines and Mills Regulations* establishing 24-month timelines for projects requiring the CNSC's regulatory review and decision on new applications for a licence to prepare a site for a Class I nuclear facility and a licence to prepare a site and construct a uranium mine and mill.

To fully implement the AMP system, the CNSC proposed regulations setting out the list of violations that will be subject to the AMP program under the NSCA, the method and criteria by which the penalty amount will be determined and the manner in which notices of violations must be served for legal purpose. The coming into force of the regulations is anticipated in the next reporting period.[1] See subsection 7.2(iv) for a more detailed description of AMPs.

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[1] In fact, they came into force in July 2013.

CNSC process for making regulations

When making or amending regulations the CNSC abides by the Government of Canada's *Cabinet Directive on Regulatory Management*, which came into effect April 1, 2012. The Directive updates and replaces the *Cabinet Directive on Streamlining Regulation* (2007) and the *Government of Canada Regulatory Policy* (1999). The *Cabinet Directive on Regulatory Management* ensures that the potential impact on health, safety, security, the environment, the social and economic well-being of Canadians, cost or savings to government, business or Canadians and the level of support of proposed regulations are systematically considered prior to creating 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 report of the initial IRRS mission in 2009 noted that the CNSC's regulation-making process is "very open and transparent with extensive pre-consultations built in to the process. Interested parties are consulted…before starting to draft the regulation" (good practice G16). The CNSC regulation-making process is described in more detail in annex 7.2(i)(a).

Response to Fukushima - CNSC regulations

In terms of the CNSC's response to Fukushima, the CNSC regulations were used to facilitate the review and the regulations themselves were subject to the review. First, the *General Nuclear Safety and Control Regulations* provided the mechanism whereby the CNSC requested NPP (and other nuclear facility licensees) to review their safety cases in the light of the lessons learned from the Fukushima accident. Subsection 12(2) of those regulations places an obligation on licensees to respond to a request from the Commission, or from a person who is authorized by the Commission, to "conduct a test, analysis, inventory or inspection in respect of the licensed activity or to review or to modify a design, to modify equipment, to modify procedures, or to install a new system or new equipment."

Second, the CNSC Fukushima Task Force reviewed the regulations and found that, overall, the regulations are sound. No changes to the *General Nuclear Safety and Control Regulations* were identified as a result of the review. However, there were recommendations to change other regulations (the *Class I Nuclear Facilities Regulations* and the *Radiation Protection Regulations*) with respect to requirements related to emergency preparedness and response - see subsection 16.1 (a) for details. These changes are not needed immediately.

7.2 (i) (b) Regulatory framework documents

General description of CNSC regulatory documents

CNSC regulatory 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.

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

The CNSC updates the regulatory framework plan quarterly to take into account new projects or changes in project plans, posting the plan on the CNSC's external Web site. The projects are organized according to a new structure, which presents all existing documents and document projects in a clear and logical manner. Documents are grouped into three categories – regulated facilities and activities, safety and control areas and other regulatory areas, as follows:

- Regulated facilities and activities are organized according to the type of regulated facility or activity. They provide guidance to applicants on the information required for licence applications and to licensees on the requirements for conducting the licensed activity. They also point to relevant expectations in the safety and control areas, where appropriate.
- Safety and control areas are the 14 technical topics used by the CNSC to assess, review, verify and report on regulatory requirements and performance across all regulated facilities and activities.
- Other regulatory areas include topics such as reporting requirements, public and Aboriginal engagement, financial guarantees for licence activities, Commission proceedings and information dissemination.

The CNSC safety and control areas are listed as follows. They are described in appendix F.

- Management System
- Human Performance Management
- Operating Performance
- Safety Analysis
- Physical Design
- Fitness for Service
- Radiation Protection
- Conventional Health and Safety
- Environmental Protection
- Emergency Management and Fire Protection
- Waste Management
- Security
- Safeguards and Non-Proliferation
- Packaging and Transport

This structure organizes the CNSC's library of regulatory documents in a clear and logical manner and facilitates stakeholder access to relevant content while ensuring regulatory requirements and guidance are available in the context of the broader regulatory framework.

The CNSC's frequency of document revision is needs-based. Documents are reviewed and revisions are planned and scheduled, in accordance with their priority and the availability of resources. Recent initiatives with respect to the management of the CNSC's regulatory framework include the establishment of a five-year review cycle for all CNSC documents. This review determines where these would be withdrawn and archived, retained as is for continued use, or scheduled for revision, depending on the outcome of the review. This process ensures that the CNSC's full regulatory framework continues to be current and reflect the latest developments in domestic and international OPEX and guidance.

During the reporting period, the CNSC modernized its approach to documenting its expectations, moving to a single document type (REGDOC) that includes both regulatory requirements and guidance in the same document for ease of understanding and cross-referencing.

Suggestion S13 from initial IRRS mission in 2009

"CNSC should review and adopt a consistent terminology for its regulatory guides."

The peer-review team for the follow-up IRRS mission in 2011 concluded that the CNSC has adopted a consistent terminology for all of its regulatory documentation and formalized its nomenclature for regulatory guides (used for all documents for all service lines). On that basis, the peer-review team closed suggestion S13.

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

Use of other standards in the development of CNSC regulatory 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 new Government of Canada *Cabinet Directive on Regulatory Management* and is consistent with the CNSC's vision of regulatory excellence.

The report of the initial IRRS mission in 2009 noted that the CNSC "adopts or adapts national and international standards when developing regulatory requirements. The Government of Canada promotes participation in standard setting activities of the IAEA and ... the Canadian Standards Association" (good practice G15).

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 the four supporting 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 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 projects have aligned with IAEA documents.

Response to Fukushima – CNSC regulatory documents

The CNSC Fukushima Task Force reviewed the regulatory documents published by the CNSC that are referenced in the NPP operating licence or licence conditions handbook (LCH), which is described in subsection 7.2(ii)(d) under "Licence Improvement Project". The overall finding was that there is no need to revisit the regulatory framework in order to identify the minimum, necessary and sufficient number of regulatory documents to support the NPP regulatory program. Should the framework be revisited in the future, the Task Force found, the NPP operating licence and LCH templates should be used as the basis for identifying needs for regulatory documents. The NPP operating licences and LCHs currently contain some regulatory requirements and expectations, respectively, that are not found in regulatory documents; when the framework is revised, the opportunity should be taken to update regulatory documents, as appropriate. The work described above, to collate and develop a long-term vision for the document framework, will address this observation.

The CNSC Fukushima Task Force also found that certain, specific CNSC regulatory documents should be updated on a priority basis (see articles 16 and 18), specifically recommending updating selected design-basis and beyond-design-basis requirements to address:

- external hazards and associated methodologies for assessment of magnitudes
- probabilistic safety goals
- complementary design features for prevention and mitigation of severe accidents
- passive safety features
- fuel transfer and storage
- design features that would facilitate accident management

Completed and ongoing projects initiated to address this recommendation include the following.

- *Guidance on Safety Analysis for Nuclear Power Plants* (GD-310; published March 2012)
- *Requirements and Guidance for Public Information and Disclosure* (RD/GD-99.3; published March 2012)

In addition, a Fukushima omnibus amendments project was initiated to provide focused amendments in response to the CNSC Action Plan. Proposed amendments were presented to stakeholders in the summer of 2012 for input and will be revised as appropriate prior to final approval by the Commission. This project includes updates to:

- *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* (S-294)
- *Developing Environmental Protection Policies, Programs and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills* (S-296 and G-296)
- *Severe Accident Management Programs for Nuclear Reactors* (G-306)
- *Deterministic Safety Analysis for Small Reactor Facilities* (RD-308)
- *Safety Analysis for Nuclear Power Plants* (RD-310)

Other CNSC regulatory document projects currently underway that address key lessons from Fukushima include the following.

- REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants* (formerly RD-337)
- REGDOC-1.1.1, *Site Suitability (*for nuclear power plants and small reactor facilities - formerly, *Site Evaluation for New Nuclear Power Plants* (RD-346))
- a new dedicated regulatory document on accident management
- a strengthened suite of emergency preparedness regulatory documents

CSA Group standards

The CSA Group (formerly the Canadian Standards Association) sets standards related to NPPs and other nuclear facilities and that complement the regulatory documents published by the

CNSC. Many of these standards are related to NPP design. Both the industry and the CNSC contribute to these standards.

During the reporting period, the nuclear industry, the CNSC and the CSA Group continued to collaborate to strengthen Canada's program for nuclear standards. A representative of CNSC senior management is a member of the CSA Nuclear Strategic Steering Committee and its Executive Committee, which are responsible for developing the suite of voluntary-consensus nuclear standards. Additionally, CNSC management and technical staff are members of the technical committees, subcommittees and working groups developing the standards. During the reporting period, the CSA Group greatly reduced the time to issue standards. Several new standards have been issued and many others have been updated or reaffirmed, as indicated in table 2 in annex 7.2(i)(b), which lists CSA standards relevant to NPPs.

The CSA Group developed its own response to Fukushima, performing an initial review of existing CSA nuclear standards and concluding that they are, in general, robust. Based on a more detailed assessment, the CSA Group developed plans that consider lessons learned from Fukushima and is integrating them into the CSA work plan. These include proposals for new CSA standards, along with revisions to several existing ones. In particular, the CSA Group began developing a new standard on emergency management, *General Requirements for Emergency Management for Nuclear Facilities* (N1600), which it plans to make available for consultation in 2013. The CNSC Action Plan assigned an action to the CNSC to support the review of CSA standards to take into account the lessons learned from the Fukushima accident, through its participation in the CSA Nuclear Strategic Steering Committee.

Incorporation of regulatory framework documents into the licence

CNSC regulatory documents and CSA standards become legally binding requirements once they are referenced in a licence. Within the current regulatory framework, there are four approaches to impose requirements from a new regulatory document or CSA standard on a licensee:

- proposal of a new licence condition at the time of licence renewal
- receipt of a licensee application for a licence amendment
- issuance of an order
- amendment of a licence by the Commission, 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).

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

During the reporting period, the CNSC continued to update its regulatory framework for new NPPs. The revised framework draws upon international standards and best practices, including the IAEA's 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.

The following CNSC regulatory documents are important parts of the suite of documents required for the licensing of new-build projects:

- *Site Evaluation for New Nuclear Power Plants* (RD-346)

- *Design of New Nuclear Power Plants* (RD-337; see article 18)
- *Safety Analysis for Nuclear Power Plants* (RD-310; see subsection 14(i)(a)

RD-310 is also being introduced in the operating licences of existing NPPs.

Information on the new-build regulatory framework and documents under development is provided in article 12 for human and organizational factors, in article 17 for siting and in article 18 for design.

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. Small reactors include reactors capable of producing radioactive isotopes, research reactors, steam production units and small-scale electrical power production units. The following CNSC regulatory documents related to small reactors were published during the reporting period:

- *Design of Small Reactor Facilities* (RD-367)
- *Deterministic Safety Analysis for Small Reactor Facilities* (RD-308)

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. 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 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 co-operation with federal and provincial/territorial government departments and agencies in such areas as health, environment, Aboriginal consultation, transportation and labour. 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 lifecycle of a Class IA nuclear facility:

- a licence to prepare a site
- a licence to construct
- a licence to operate
- a licence to decommission

- a licence to abandon

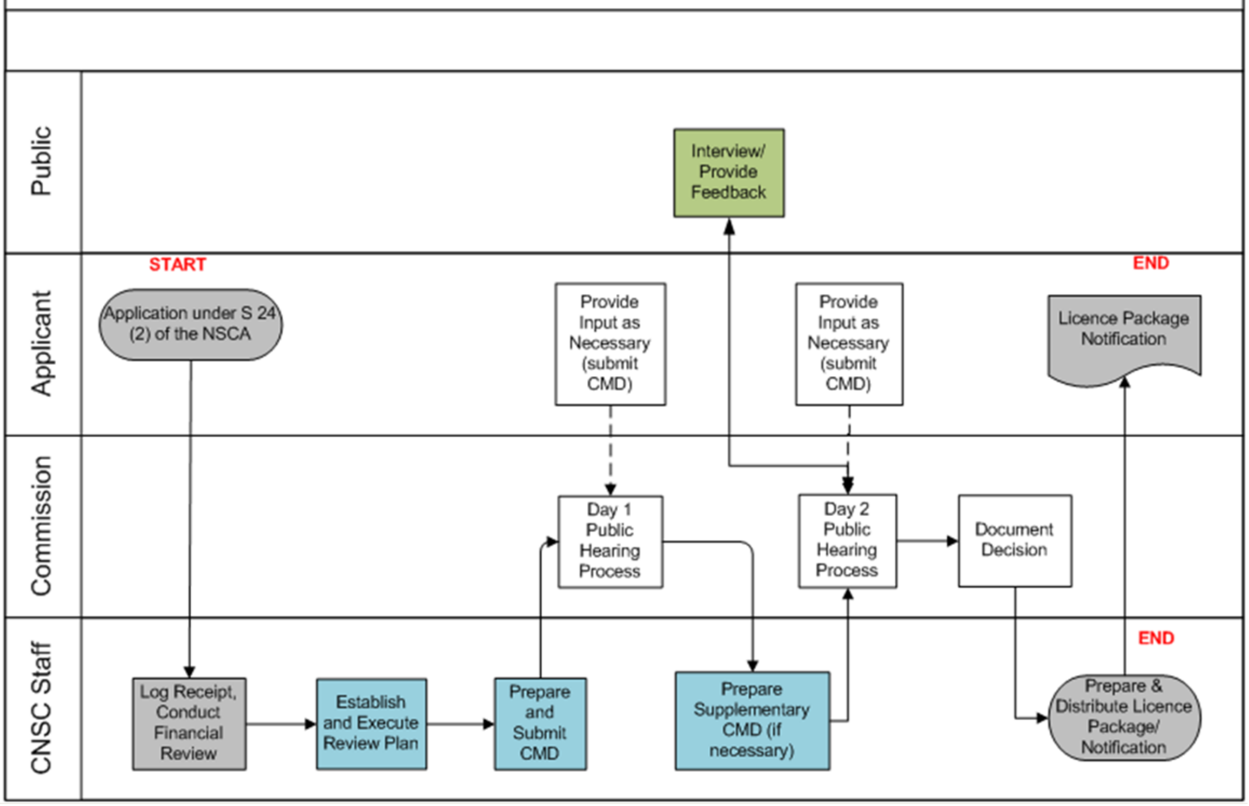
The NSCA does not have provisions for combined licences for site preparation, construction, or operation. However, applications for licences to prepare a site for, construct and operate a new nuclear facility can be assessed in parallel provided the applicant submits supporting information and evidence.

7.2 (ii) (a) Licensing process

The CNSC information document *Licensing Process for New Nuclear Power Plants in Canada* (INFO-0756, rev. 1) clarifies the current licensing process in the context of the NSCA. The CNSC licensing process is one of the core processes in the CNSC Management System, which is described in subsection 8.1(d).

Figure 7.2 depicts the CNSC licensing process and the key activities to be carried out by the licence applicant, CNSC staff and the Commission.

Figure 7.2: The process of Obtaining an NPP Licence under the Nuclear Safety and Control Act



The report of the initial IRRS mission in 2009 noted that 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…" (good practice G4).

The Fukushima review during the IRRS follow-up mission to Canada also found that the "CNSC has adequately addressed the authorization process in its review of the implications of the lessons learned from the TEPCO Fukushima Daiichi accident."

The licensing process is initiated when the proponent sends an application to the CNSC. A licence application must contain sufficient information to meet regulatory requirements and to demonstrate that the applicant is qualified to 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 identified in the *General Nuclear Safety and Control Regulations* and the *Class I Nuclear Facilities Regulations*.

Bases for important requirements for licence applications

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

To enhance clarity, 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 licence application guide *Licence to Construct a Nuclear Power Plant* (RD/GD 369) was published in 2011. The application guides for the licence to prepare a site and licence to operate an NPP are under development.

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 so that the facility does not pose any unnecessary risk in the event that the licensee can no longer operate the facility. To date, these have mostly been used for decommissioning an NPP at the end of its operating life and for the long-term management of spent nuclear fuel. Information on proposed financial guarantees should include any obligations for funding the decommissioning and long-term management of nuclear fuel waste, pursuant to the *Nuclear Fuel Waste Act*.

The *Canadian Environmental Assessment Act* (CEAA) stipulates that an environmental assessment (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 a site – is issued. An EA addresses all the phases of the project lifecycle (from site preparation through to abandonment). EAs are described in more detail in subsection 17(ii)(a).

Definition of licensing basis

The information submitted with a licence application is part of the licensing basis for the NPP. The concept of the licensing basis is articulated in CNSC information document *Licensing Basis Objective and Definition* (INFO-0795). 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.

CNSC 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 Harmonized Plan for Improvement Initiatives (referred to herein as the Harmonized Plan, 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, the Nuclear Energy Agency (NEA), the Multinational Design Evaluation Programme (MDEP) and other nuclear regulators. Both the EA reviews and the licensing reviews are executed by CNSC staff using a project-specific assessment plan within a project management framework. The assessment plan triggers specific reviews, to be conducted by CNSC specialists using topical staff work instructions (see subsection 8.1(d)). The CNSC has assessment plans and staff work instructions for the following projects:

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

The CNSC has also completed almost all the staff work instructions needed to assess an application for a licence to construct an NPP.

During the reporting period, in support of conducting specific reviews, the CNSC continued to develop and integrate a comprehensive set of technical assessment criteria matrices across all service lines.

Recommendation R3 from initial IRRS mission in 2009

"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."

The peer-review team for the follow-up IRRS mission in 2011 observed that the CNSC made effective progress in addressing the recommendation. The team noted that implementation of the improvements was completed for the licensing and certification processes across all regulated facilities and activities and that the implementation of a standardized and systematic approach for technical assessment was progressing well (see IRRS suggestion S15, below, for further details). The peer-review team closed recommendation R3 on the basis of progress and confidence.

During the reporting period, the CNSC also finalized the completion of relevant staff work instructions and criteria to support vendor design reviews (described in article 18). In addition, the CNSC continued the development of regulatory documents and guides and application guidance for new-build projects, as described in subsection 7.2(i)(b).

Recommendation R6 from initial IRRS mission in 2009

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

The peer-review team for the follow-up IRRS mission in 2011 observed that the CNSC was systematically pursuing the necessary preparations for the licensing of new-build, including process documentation, regulatory documents and guides, application guides and forms and staff assessment plans and review procedures. Given that the preparations were being carried out following the CNSC's Management System processes and governance and integrated in the planning process, the peer-review team closed recommendation R6 on the basis of progress and confidence.

Suggestion S15 from initial IRRS mission in 2009

"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."

The peer-review team for the follow-up IRRS mission in 2011 noted that the CNSC developed a process, "How to Conduct a Technical Assessment", to ensure all staff follows the same process. Given the progress achieved during this project, the peer-review team closed recommendation R6 on the basis of progress and confidence.

During the reporting period, the CNSC completed work on the corporate process for consistency in planning and conducting technical assessments across all service lines.

Licensing recommendations, decisions and related approvals

The CNSC is obligated to comply with any federal legislation and therefore may make its regulatory decisions in consultation with any department or agency government bodies at the federal level having independent but related responsibilities with the CNSC. The CNSC assesses an applicant's supporting information with input from other federal and provincial government

departments and agencies responsible for regulating health and safety, environmental protection, emergency preparedness and transportation of dangerous goods in relation to nuclear-related projects. The CNSC maintains memoranda of understanding (MoU) with these departments and agencies.

CNSC staff document the conclusions and recommendations from their reviews in Commission member documents (CMDs), submitting them to the Commission. The Commission considers the initial conclusions and recommendations at the Day One public hearing (refer to figure 7.2), along with information provided by the licence applicant. At the Day Two public hearing, the Commission, in accordance with the *Canadian Nuclear Safety Commission Rules of Procedure,* invites interventions by other interested parties, who are then given the opportunity to present information that they feel is relevant to the licensing decision at hand. For the licensing of NPPs, intervenors are typically allotted significant periods of time at the Day Two hearing to present their information and engage the Commission. The CNSC staff and applicants may also present supplementary or revised information at the Day Two hearing (e.g., as follow-up to discussion at Day One). The hearings are webcast.

During and after public hearings, the Commission 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, along with the reasons for the Commission's decisions, are posted on the CNSC Web site.

If the Commission decides to issue a licence, the information submitted with a licence application becomes a legal requirement for the licensee (part iii of the licensing basis). Licences may also contain other terms and conditions, such as references to regulatory documents or industry standards, which licensees must meet.

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

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

The licence sets up the situations, changes, or conditions under which such decisions are to be made by the Commission (called an approval) and to whom, if anyone, the Commission can delegate the authority to make the decision on behalf of the Commission (called a CNSC staff consent).

Examples of Commission approval and CNSC staff consent were included in the licence to operate for Point Lepreau that was in effect during the first half of the reporting period. That licence covered the remainder of the refurbishment outage for Point Lepreau and included a number of "hold points". One licence condition imposed the requirement for the licensee to obtain Commission approval following refurbishment and prior to reloading fuel. Another licence condition imposed the requirement for the licensee to obtain Commission approval, or consent of a person authorized by the Commission, prior to restarting the reactor and for each staged increase in reactor power during commissioning tests. These hold points were exercised during the reporting period.

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

The selection of a site for the long-term development of a new NPP is not, in itself, a regulated activity in Canada (although the activities of site characterization and evaluation, which support site selection, are regulated). The choice of site is largely a matter between the project proponent and the municipalities and provinces/territories involved. The only exception to this practice is when the federal government, under NRCan, 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 a site, it is the applicant's responsibility to demonstrate to the CNSC that the proposed site is suitable for future development and that the activities encompassed by the licence will not pose unreasonable risks to health, safety, security and the environment for the site and its surrounding region. In addition to addressing the activities pertaining to site evaluation and site preparation, submissions for selected topics for the licence to prepare a site are expected to consider the entire lifecycle of the proposed facility. The applicant must also demonstrate that the proposed licensed activity meets all applicable regulatory requirements.

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

- 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 (QA) and public and Aboriginal consultation

Additional information on the site evaluation criteria in RD-346 and the level of certainty and detail required for the design, 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 was compiled in a draft regulatory document during the reporting period and provided for public consultation. The 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 public information meetings, held by the applicant, where the public can express its views and question the applicant (see subsection 9(c) for an example).

The CNSC review process (shown in figure 7.2) utilizes an assessment plan with defined review stages and timelines. CNC staff work instructions are used to coordinate the CNSC's review of applicant's submissions of the EIS and application for a licence to prepare an NPP site. Public information meetings and the discussions that follow, also assist in judging the acceptability of the site.

7.2 (ii) (c) Licence to construct

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

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

During the reporting period, the CNSC published its regulatory document *Licence Application Guide: Licence to Construct a Nuclear Power Plant* (RD/GD-369) to provide additional guidance regarding construction licence applications. The development of this document utilized the 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 considers the application for a licence to construct. 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 organization 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 (see article 17 for further discussion) — the 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)
- any independent peer review of the safety assessment, as stipulated in the CNSC document *Design of New Nuclear Power Plants* (RD-337); such review would be conducted by individuals or groups separate from those carrying out the design and would include a clause-by-clause assessment against 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 organization 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 QA 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
- assessment of the effectiveness of applicant's oversight of construction and commissioning activities
- granting of Commission approval or CNSC staff consent 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 SSCs 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 the anticipated 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 that 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 components (SSCs), including their design and operating conditions
- the final safety analysis report
- proposed measures, programs, policies, methods and procedures for:
  - Phase B, C and D commissioning—which is commissioning of all SSCs with first fuel in the core
  - operating and maintaining the NPP
  - handling nuclear substances and hazardous materials
  - controlling releases of nuclear substances and hazardous materials into the environment
  - preventing and mitigating the effects on the environment and health and safety of persons resulting from plant operation and decommissioning
  - assisting offsite authorities in emergency preparedness activities, including procedures to deal with an accidental, offsite release
  - 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 regulatory document currently under development.

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 SSCs, to confirm the following:

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

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

The initial operating licence is expected to be issued with conditions (hold points) to load fuel, permit reactor start-up and allow operation at power in steps up to the NPP design rating. 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 previous performance and findings of compliance-verification activities. During the reporting period, the typical NPP operating licence period was five years. The imposition of a shorter licence period by the Commission is an option where overall licensee performance is unsatisfactory or because of other considerations. The licensee may also request a specific licence period to match its planned activities or anticipated change in status (such as the beginning or end of refurbishment).

CNSC Commission member document (CMD) 02-M12 compiles factors for CNSC staff to consider when making recommendations to the Commission regarding licence periods. 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 under the CNSC safety and control areas (described below)
- requirements of the CNSC *Cost Recovery Fees Regulations*
- the facility's planning cycle

Licence amendments

The NSCA gives the Commission the authority to 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, or at the request of the licensee and can be executed relatively quickly if necessary. This ability enables the CNSC to effectively address safety-related and other issues at the licensing level.

Licence renewals

For the renewal of a licence to operate, the licensee must indicate any changes in information submitted in the previous application. Appendix C provides a summary of information required to accompany an application to renew an NPP operating licence. This type of information becomes part of the licensing basis of the NPP once a licence to operate is granted, as described in subsection 7.2(ii). The CNSC plans and conducts a balanced assessment of the licensee programs and activities. See subsection 14(i)(b) for a description of this assessment. The assessment is used to provide the Commission 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.

Licence renewal is one of the options, as listed in subsection 7.2(i)(b), for imposing the requirements from new regulatory documents or standards on licensees. New standards and requirements are systematically incorporated into each operating licence when it is renewed, thus contributing to the continuous safety improvement of the NPPs. This is regarded as a strength of the Canadian system. Before incorporating a new regulatory document or 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/implementation plan to achieve full compliance. The implementation of CNSC regulatory documents frequently involves a series of consultations, such as CNSC-industry workshops and CNSC staff visits to NPPs.

To address the lessons learned from Fukushima, the CNSC Fukushima Task Force examined the option of adding new regulatory documents or standards to operating licences through the licence renewal or amendment processes. The Task Force found that two new safety requirements should be gradually added (in the medium- to long-term) to the NPP licences to operate. They would be linked to two new regulatory documents related to accident management (see subsection 19(iv)) and public information programs (see subsection 9(c)).

During the reporting period, the licences to operate Pickering A, Pickering B, Gentilly-2, Point Lepreau and Darlington were renewed.

Life extension within framework of the licence to operate

The CANDU reactors in Canada have a typical design life of about 30 years, after which a re-assessment is required to justify further operation. Given that the typical duration of a licence to operate is five years, activities associated with life extension are governed in part, by the conditions in the licence to operate that are in effect before life extension, during life extension and during return to service following life extension.

The CNSC document *Life Extension of Nuclear Power Plants* (RD-360) 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.

In accordance with RD-360, licensees planning life extensions are required to carry out an ISR based on IAEA guidance.[2] 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. OPEX in Canada and around the world, new knowledge from research and development activities and advances in technology are all taken into account.

RD-360 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* (CEAA), 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:

- The technical scope of the project takes into account the results of an EA (see subsection 17(iii)(b)) and an ISR and is adequately reflected in an integrated implementation plan.
- Programs and processes take into account the special considerations of the project.

[2] RD-360 cites IAEA safety guide NS-G-2.10, which was replaced in 2013 by IAEA Specific Safety Guide No. SSG-25 *Periodic Safety Review for Nuclear Power Plants*.

- 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, rank the shortcomings in terms of safety significance and prioritize corrective measures and safety improvements.

The CNSC is preparing RD-360 version 2, which will broaden the licensees' options for a) the operation of NPPs beyond their original design lives and b) the cessation of commercial operations. The public consultation of the document was closed at the end of 2012; it is expected that the new version of RD-360 will be completed during the next reporting period.

As part of the ISR, licensees perform a review of the NPP against modern standards and practices. Identified gaps are reviewed and practicable upgrades are incorporated into the integrated improvement plan. The licensees are expected to fill the gaps as far as reasonably practicable.

A major part of the assessment is to determine the condition of safety-related SSCs.

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 (regulatory hold point) is contingent upon the licensee's demonstration that all relevant licence conditions have been met.

The following describes the basic approach taken for the life extension work executed during the reporting period. Assessments associated with the work are described in subsection 14(i)(g). Safety improvements that were implemented during life extension are described in annex 18(i).

Bruce A refurbishment

Refurbishment of Units 1 and 2 for life extension and continued operation was completed during the reporting period under the guidance of CNSC regulatory document RD-360. Bruce Power completed a thorough evaluation of safety and issued an ISR whose findings were implemented as part of the Bruce A return–to-service project.

Point Lepreau refurbishment

Refurbishment of Point Lepreau for life extension and continued operation was completed during the reporting period. The refurbishment of Point Lepreau is particularly interesting because the Fukushima accident occurred during the refurbishment. Several of the potential safety improvements identified by the Task Force had been or were already being implemented by Point Lepreau as part of its refurbishment. This reinforced the effectiveness of the ISR process as a mechanism for identifying and prioritizing tangible safety improvements.

Pickering B incremental life extension

An extensive ISR was completed in 2010 to assess OPG's options for the ongoing service of Pickering B. OPG decided that incremental life extension was the best option, rather than the options of station shutdown or refurbishment (see subsection D.2 of the Introduction for discussion). The ISR provided valuable input into the continued operations plan and sustainable operations plan, which were developed in 2010 and 2011, respectively.

In 2010, OPG developed a continued operations plan to document the technical basis actions required to support the incremental life extension of the Pickering B units to the end of 2020. It integrates the improvements necessary to close issues identified in the EA and ISR for Pickering B and is updated annually. OPG used a draft revision of the CNSC regulatory document *Life Extension of Nuclear Power Plants* (RD-360) to systematically identify activities (i.e., analyses, upgrades, studies or modifications) required to provide the technical basis for continuing operation of the Pickering B units. Since 2011, OPG has completed more than half of the activities identified in the Pickering B continued operations plan, with the remaining actions scheduled for completion prior to entering into the incremental life extension time frame.

In 2011, OPG developed a sustainable operations plan for Pickering A and B that documents strategies, direction and actions to address the unique challenges, constraints and risks associated with the approach to the end of commercial operation. The sustainable operations plan, which is also updated annually, describes the arrangements and activities required to demonstrate that safe and reliable operation of Pickering will be maintained and sustained, for each of the 14 CNSC safety and control areas, for the period of operation up to until each reactor unit's permanent shutdown. For the majority of safety and control areas, no changes are anticipated from a program perspective. The changes and plans deal primarily with people issues and with business issues pertaining to the life expectancy of the plant. The sustainable operations plan also contains some preliminary information about the first stages of decommissioning.

Licence improvement project

The CNSC's Licence Improvement Project for Class I facilities was initiated in 2008, under the Harmonized Plan. Class I facilities, as defined in the *Class I Nuclear Facilities Regulations*, include NPPs and research reactors (Class IA facilities) as well as Class IB facilities such as fuel fabrication facilities. The project was initiated to address specific issues:

- There was a lack of clarity over what aspects of the licensee's provisions were covered by the licence.
- The distinction among requirements for the licensee, compliance criteria used by CNSC staff and guidance provided to the licensee was not clear.
- Low-risk, administrative changes were triggering many licence amendments by the Commission.

The project has developed 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)
- basis and experience with current licences
- consultations with internal and external stakeholders

During the reporting period, the project generated greater consistency of licence formats across CNSC-regulated major facilities. For NPPs, all renewals resulted in the Commission issuing an operating licence in the improved, streamlined structure and format. Features of the new structure and format include:

- 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's approval
- removal of redundant conditions from the licences
- clear, well-defined and streamlined licence conditions following, as far as practicable, the CNSC safety and control 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

The first condition of the new, streamlined operating licences is that the licensee must operate the NPP in accordance with its licensing basis (as defined in subsection 7.2(ii)). The licensee can improve its provisions, operations or facility design as long as the improvements are within the licensing basis and executed according to the licensee's management system. However, the licensee must obtain the written approval of the Commission if it wants to make a change outside the licensing basis. The second licence condition of the streamlined operating licences requires the licensee to notify the CNSC when it changes the documentation comprising part iii of the licensing basis (defined in subsection 7.2(ii)(a)).

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 that are used by CNSC staff to confirm compliance with the licence condition. The compliance verification criteria in NPP LCHs are extracted from the licensing basis.

The LCH also provides for the management of records and documents, including the process by which the licensee notifies the CNSC of changes to its documentation comprising part iii of the licensing basis.

The compliance verification criteria in the LCH document implementation plans, action items and transition dates for specific licence conditions. These criteria provide the latest revisions and effective dates of the CNSC regulatory documents and industry standards cited in the licence. The criteria also provide information on obtaining Commission approval or CNSC staff consent of specified changes and for reviewing the other changes that the licensee makes to its documentation.

The NPP LCH also provides recommendations and guidance for each licence condition, which include non-mandatory suggestions or advice on how the licensee can comply with the licence condition and otherwise improve its safety performance in the area covered by the licence condition.

In the new, streamlined operating licence format, if the licensee or CNSC proposes to change the version of a particular regulatory document or standard that is cited in the licence, the change can be executed by CNSC staff as long as the new version is at least as "safe" as the existing one. The change would be recorded in the LCH by the director general of the Directorate of Power Reactor Regulation. By comparison, in the previous format of the operating licences, such a change would have required the approval, from the Commission, of a licence amendment to implement this type of change. By structuring the requirements in this way, the CNSC is improving its efficiency and effectiveness.

Recommendation R4 from initial IRRS mission in 2009

"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."

The peer-review team for the follow-up IRRS mission in 2011 noted that sufficient progress had been made in the reform, as licences for all types covered by the recommendation are being gradually renewed in the new, more consistent and simpler format that will reduce the need for and work associated with, licence amendments. The new licences are being accompanied by an LCH in all cases. On that basis, the peer-review team closed recommendation R4.

By the end of the reporting period, all NPPs had an operating licence in the new, streamlined format and an accompanying, NPP-specific LCH. Generic templates for both the NPP operating licence and LCH have also been introduced to optimize consistency among NPPs. As NPP operating licences are renewed, the templates are used to develop the licence and the LCH for that NPP.

Suggestion S5 from initial IRRS mission in 2009

"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."

The peer-review team for the follow-up IRRS mission in 2011 noted that improved efficiency and effectiveness were being achieved through the licence reform project (see recommendation R4, above). On that basis, the peer-review team closed suggestion S5.

7.2 (iii) System of regulatory inspection and assessment

The Commission issues licences to applicants qualified to operate the NPP and that will adequately provide for the health and safety of persons and the protection of the environment, in accordance with subsection 24(4) of the NSCA. 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. Per paragraph 24(4)(b) of the NSCA, these inspections are intended to confirm that the licensee has adequate provisions to adequately protect the environment and the health and safety of persons and to maintain national security and measures required to implement Canada's international obligations. These provisions cover the areas listed in appendix C.

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

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 initial issuance of licences and 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; and 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 are reviews of documentation submitted to the CNSC by licensees (or applicants)
- surveillance or continuous monitoring, which includes the review of station records; attendance at meetings related to production, return to service and outage planning; and walkabouts in the field

Desktop reviews include reviewing licensee documents, such as the station safety analysis reports, quarterly reports or event reports, against relevant requirements. See annex 7.2(iii)(b) for more examples of reports that licensees submit to the CNSC. Some specific forms of desktop review are supported by CNSC staff work instructions to ensure consistency of approach and to optimize regulatory effectiveness and efficiency.

Desktop reviews are also conducted when licensees propose certain changes to their operations, documentation, etc. In some instances, such changes require Commission approval or CNSC staff consent before being executed, as stipulated in licence conditions. CNSC staff would perform desktop reviews to confirm that the change, if it proceeds, would remain within the licensing basis for the facility. For those changes that do require approval/consent, CNSC staff could still perform similar reviews to confirm the change is within the licensing basis.

In general, acceptance criteria that can be used to assess compliance during desktop reviews or inspections may be derived from two sources: compliance verification criteria in the LCH that is extracted from the licensing basis and criteria that is not in the LCH but is derived from one or more of the following:

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

Inspections

Inspections typically include interviews with responsible licensee staff, along with reviews of documentation, data, logs and event reports; and field component line-up checks.

Some inspections monitor licensee activities as they unfold (e.g., exercises or outages). Other surveillance and monitoring activities provide the means to the collection of real-time information about licensee performance and possible emergent issues.

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 inspectors are designated per section 29 of the NSCA and have various powers and limitations described in sections 30 to 35 of the NSCA (see subsection 8.1(b) for further details). A site office inspector generally leads the inspection team, with support from the technical specialist staff. The licensee is notified in advance of the inspection and its subject area. Entrance meetings, daily briefings of results and exit meetings are included in the inspection plans. The results are recorded in a CNSC report to the licensee and follow-up actions are documented and assigned target completion dates.

Type I inspections are used to evaluate licensee programs that address the topics listed in appendix C.

CNSC staff conduct Type II inspections to assess compliance. A suite of inspection guides was updated during the reporting period and additional guides were developed to support their conduct. The guides are continuously improved to reflect the current state of the CNSC compliance program and changes to the licensing basis.

The results of Type II inspections are transmitted by letter to 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.

For example, immediately after the Fukushima accident, CNSC site staff performed walkdowns at Canadian NPPs to verify the licensees' emergency preparedness for external hazards and severe accidents. The inspection was done so that the CNSC could reassure the Commission and Canadian public that certain aspects contributing to the events in Japan had been specifically verified. These aspects included seismic, fire, backup power availability and condition, hydrogen igniters and irradiated fuel bays. The readiness of emergency staff and installed equipment was also verified and no actions were assigned to the licensees as a result of these inspections. See Canada's report for the Second Extraordinary Meeting for more details.

To help achieve regulatory effectiveness, efficiency, consistency and clarity, the CNSC compliance program uses a planned set of baseline inspections. It represents the minimum set of compliance activities required to verify licensee compliance with regulatory requirements. The baseline set was established by identifying a group of inspections (and desktop reviews), as well as promotion activities for typical NPP operation (e.g., for those programs that address the areas listed in appendix C and for the systems and areas listed in table 1 in annex 7.2(iii)(b)). Inspections were then assigned to the CNSC safety and control areas. The baseline set was subsequently refined to represent a reasonable set of inspections for a licensee having acceptable ratings in the safety and control 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 and control areas where the CNSC rating of licensee performance is below expectations, risk management principles are used to identify focused activities that CNSC staff will undertake in the next period to supplement the baseline inspections. Monitoring includes the quarterly review of results of all verification activities.

The risk-informed approach was commended by the peer-review team for the initial IRRS mission in 2009, which noted in its report that 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" (good practice G11).

Some improvements to the NPP inspection program have been 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 initial IRRS mission in 2009

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

The peer-review team for the follow-up IRRS mission in 2011 noted that the CNSC had developed a comprehensive process "How to Conduct Inspections" that applied to all service lines (not just Class I facilities, which include NPPs). Also noting the degree of integration of this process with service-line-specific processes and procedures, the peer-review team closed recommendation R8 on the basis of progress and confidence.

Another CNSC program that has also helped enhance the coherency and consistency of inspections is the inspector training and qualification program (see subsection 8.1(c) for details)

Response to Fukushima – compliance process

The CNSC Fukushima Task Force reviewed the CNSC's programs that verify compliance by licensees with regulatory requirements. The Task Force found that CNSC staff should review the compliance program for needed improvements once the identified changes to the regulatory framework have been implemented. Currently, various "one-of-a-kind" compliance activities are used to assess the licensees' responses to Fukushima action items. The CNSC Fukushima Task Force is currently drafting a process to help CNSC staff determine if these unique compliance evaluations are sufficient, or if new evaluations will be required that correspond to the new requirements being developed. This will lead to the recommendation of changes to the content of the CNSC inspection guides, as per the existing process for continuous improvement of the inspection guides.

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 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 events or situations that are outside the normal operations described in the licensing basis. Significance is determined using operational procedures or expert judgment. The urgency with which follow-up to the event should be conducted is also evaluated. The CNSC reviews do not aim to duplicate 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. CNSC staff may also investigate events of higher safety significance to independently confirm the event causes and required corrective actions.

A 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 to track licensee and CNSC follow-up. The report of the initial IRRS mission in 2009 noted that the "CERTS application developed for event inspection, assessment and corrective action tracking constitutes an efficient tool for event tracking, related inspections and corrective actions" (good practice G12).

Situations deemed to be of noteworthy significance with respect to the protection of health, safety and the environment; the maintenance of national security; and compliance with international obligations, are reported to the Commission in an "event initial report" (referred to as early notification reports in the fifth Canadian report) 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 uses the set of 15 safety-related performance indicators that are defined in S-99. 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 the *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants*

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 S-99.

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

Annual summary

The CNSC prepares an annual staff report, to the Commission and the public, 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 and control areas and determine the integrated plant rating 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 uses a variety of performance indicators to illustrate safety performance. As well, the annual staff report describes major developments, initiatives, issues and challenges during the year as related to the operating NPPs.

CNSC requirements and performance expectations in the 14 safety and control areas were met or exceeded at the NPPs for the three years of the reporting period, with only two exceptions (both of them in 2010). In the two safety and control areas where CNSC expectations were not met, the licensees implemented corrective action plans to address any shortcomings. A summary table of the ratings during the reporting period is provided in appendix F. The ratings of specific safety and control areas are cited in this report under specific articles, where relevant.

CNSC regulatory document S-99, published in 2003, will eventually be superseded by a more modern standard for reporting to support the NPP regulatory program's licensing and compliance needs. The new regulatory document, REGDOC 3.1, will set out the requirements for the submission of event and compliance monitoring reports used by CNSC staff in the management of regulatory programs. The document will provide reporting criteria that take into account the CNSC licence improvement project, the new CNSC safety and control areas, modernized safety performance indicators and reporting management processes. It will contribute to the simplification of the criteria for licence conditions set out in the LCHs.

Other objectives taken into account when developing REGDOC 3.1 include:

- eliminating the duplication of reporting requirements found in S-99 from those found elsewhere in the NSCA, in regulations and other regulatory instruments
- simplifying reporting by separating event reporting from compliance reporting
- streamlining reporting requirements for industry

REGDOC 3.1 will set out the CNSC's requirements for reporting thresholds of events and for self-reporting of compliance monitoring by operating NPPs. The scheduled compliance reports are based on the safety and control areas. The reports will include information about non-compliance events that the CNSC will use for trending and analysis. A new rationale will be established for quarterly and annual reports to demonstrate compliance with the licence. Quarterly reports, which include safety performance indicators, are designed to highlight areas of potential non-compliance with regulations and licence conditions. Annual reports provide information on program status and performance.

As part of this project, CNSC is updating and modernizing its set of safety-related performance indicators to cover more of the safety and control areas.

Publication and implementation of REGDOC 3.1 is scheduled during the next reporting period.

7.2 (iv) Enforcement

Enforcement includes all activities to compel a licensee into compliance and to deter non-compliance with legal requirements. The choice of enforcement tool is governed by the CNSC process to select and apply enforcement tools, which is based on a graduated approach. The process provides details on the effective application of the enforcement tools described below and outlines the responsibilities of CNSC staff and the Commission in their execution. In the graduated approach, 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
- industry-specific strategies

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

- written notices
- increased regulatory scrutiny
- requests from the Commission for information
- orders
- licensing actions
- prosecution

The first two types of enforcement in the list – written notices and increased regulatory scrutiny – are less formal and do not require the involvement of the Commission (they are typically handled at CNSC staff level).

Written notices are the most common enforcement tools used for NPPs. There are three types of written notices: recommendations, action notices and directives.

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

An action notice is a written request that the licensee take action to correct a non-compliance that is not a direct contravention of the NSCA, the applicable regulations, or a licence condition, but that can compromise safety, 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 acceptance criteria not directly referenced in the applicable regulations or licence conditions
- a significant, but non-systemic failure to comply with the licensee's own policies, procedures or instructions that have been established to meet licensing requirements (including programs and internal processes submitted in support of a licence application)

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

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

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

The Commission or an authorized person can make a formal request, as stipulated in subsection 12(2) of the *General Nuclear Safety and Control Regulations*. These types of formal requests are infrequent. The licensee can be requested to explain how it plans to address a concern raised by the Commission or the authorized person. For example, during the reporting period, such requests were issued to the NPP licensees to provide information related to safety issues raised following Fukushima. See subsection 8.1 for details.

The NSCA gives the Commission, inspectors and designated officers of the Commission the authority to issue an order without prior notice, where necessary to do so in the interests of health, safety, national security, or Canada's international obligations. The NSCA includes provisions for review of orders by the Commission, which includes an opportunity for the affected licensee to be heard. Orders to NPP licensees are rare – there were none during the reporting period.

Examples of licensing activities include the following:

- Short-term licence or extension: The Commission could grant a licence for a shorter term – for example, so that it can reconsider a specific compliance issue in the relatively near future. Alternatively, the Commission could also grant a short-term extension to allow the licensee sufficient time to make certain improvements or provide clarifications before the licence is considered for renewal.
- Licence amendment: CNSC staff may recommend a licence amendment to the Commission. The licensee is notified in writing of the proposed action and is given an opportunity to be heard by the Commission. Licence amendments cover a wide range of possibilities and are decided on a case-by-case basis. Examples of licence amendments include the following:
    - limitations to on-power operation

    - a requirement to obtain Commission approval before reactor start-up
    - a requirement to appear before the Commission on a regular basis, to provide status reports on progress in improvements to operation and maintenance programs
- Revocation of personnel certification
- Licence suspension or revocation: CNSC staff may recommend to the Commission to suspend or revoke a licence. This course of action can be taken in any of the following circumstances:
    - the licensee is in serious non-compliance
    - the licensee has been successfully prosecuted
    - the licensee has a history of non-compliance
    - the CNSC has lost confidence in the licensee’s ability to comply with the regulatory requirements

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

Where warranted, prosecution is also an enforcement option. 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

The CNSC process to select and apply enforcement tools does not include follow-up and tracking of responses to enforcement action. However, during the reporting period, an action tracking tool was completed under the Harmonized Plan, in order to track the follow-up to non-compliances and help ensure appropriate and timely responses.

Suggestion S11 from initial IRRS mission in 2009

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

The peer-review team for the follow-up IRRS mission in 2011 noted that the CNSC had completed the development of the action-tracking tool as part of the larger regulatory information bank – a licensing and compliance management control tool. This tool connects facts from regulatory activities and corresponding regulatory requirements to develop regulatory findings (conclusions). On that basis, the peer-review team closed suggestion S11.

During the reporting period, the CNSC initiated the introduction of a new enforcement tool - administrative monetary penalties (AMPs). AMPs are monetary penalties imposed by the CNSC, without court involvement, for the violation of a regulatory requirement. They can be applied to any person or corporation subject to the NSCA. AMPs were proposed in order to enhance the robustness and effectiveness of the enforcement regime and to serve as a credible deterrent, thereby achieving higher levels of compliance.

The development of AMPs involves three activities. First, the NSCA was amended in 2012 to enable the CNSC to issue AMPs (see subsection 7.1(a)). Second, the CNSC is currently drafting regulations to detail the AMP system.[3] Third, the CNSC is currently developing the internal program and processes to administer AMPs, pending the outcome of public consultations on the new regulations.

The amendments to the NSCA set the maximum AMPs for individuals and corporations at $25,000 and $100,000, respectively. AMPs are not part of the CNSC's cost-recovery mechanism – they are payable to the Government of Canada's Consolidated Revenue Fund. The amendments address the rules surrounding violations and designate who can issue AMPs and review them. The review framework is based on the current CNSC appeal process; reviews are conducted by the Commission, during which time payment is pending.

The draft regulations propose three levels of violation for the purposes of AMPs – low, medium and high regulatory significance – with each having a corresponding monetary penalty range less than or equal to the maximum amount set by the NSCA. The draft regulations propose that the exact amount of an AMP be based on:

- the history of compliance with regulatory requirements of the person or organization that committed the violation
- the degree of intention or negligence on the part of the person or organization that committed the violation
- the harm that resulted, or that could have resulted, from the violation
- whether the person or organization derived any competitive or economic benefit from the violation
- whether the person or organization made reasonable efforts to mitigate or reverse the effects of the violation
- whether the person or organization provided all reasonable assistance to the CNSC

[3] See subsection 7.2(i)(a), where it is noted that AMPs actually came into force in July 2013, after the end of the reporting period.

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* (see subsection 8.1 (d)), is "to be the best nuclear regulator in the world". This vision is supported by a commitment to self-assessment, peer review and continual improvement. The CNSC strives to adjust to changing circumstances and learn from events. In 2013, the CNSC hosted the IAEA International Conference on Effective Nuclear Regulatory Systems to help identify and promote regulatory best practices. The CNSC strongly endorses the conclusions of the conference, which state:

- Peer reviews must clearly include national action plans and follow-up missions to complete the process;
- While regulators perform detailed assessments of regulatory requirements, systems and processes following significant operational events, they do not have a systematic way of collecting, analyzing and sharing regulatory experience, nor do they routinely assess less significant events and issues which would contribute toward continuously improving the regulatory process;
- Spent fuel pool safety should be reviewed regarding obvious weaknesses in defense in depth and possible new mechanisms to eliminate as far as possible the possibility of serious accidents occurring;
- Emphasizing the importance of communication, coordination and consistency in national and international responses to emergencies, regulators should ensure that national communication plans are developed, tested, implemented and improved well before any accident occurs;
- Introducing a nuclear power programme entails a wide range of long term safety and security infrastructure issues, including the establishment of an effective nuclear regulatory system, as well as responsibilities that go beyond national borders. Regulators should use the IAEA peer review process as early as possible, report the results openly and take the needed follow-up actions;
- Projected growth in nuclear power combined with retiring experts will require a workforce with the skills necessary to face these challenges. A more consistent, international effort is still needed and the IAEA was called upon to take further actions on these issues;
- Regulators must promote a blame-free, but accountable safety and security culture, recognizing that humans are fallible and promoting the concept of shared accountability – that good system design and staff's good behavioral choices together produce good results.

(See more details at http://www.iaea.org/newscenter/news/2013/regeffectiveness.html.)

Follow-up IRRS mission to Canada

Canada hosted its initial Integrated Regulatory Review Service (IRRS) mission in 2009. The results, findings and the CNSC's planned follow-up were described in the fifth Canadian report.

In December 2010, the Government of Canada requested a follow-up IRRS mission to review the measures taken to address the recommendations and suggestions from the initial mission. The CNSC requested the addition of two new review areas – a new (at that time) IRRS core module focusing on the regulatory implications of the Fukushima accident and a module on the regulation of the transport of radioactive material.

The follow-up peer-review team consisted of 15 members, representing eight countries and the IAEA. They completed their review, including a draft mission report, during their visit to the CNSC from November 28 to December 9, 2011. The mission included observations of regulatory activities and a series of interviews and discussions with key CNSC personnel and staff of other organizations, including an NPP licensee and Health Canada. Further information on the approach and work method of the team is provided in the final mission report, which was issued in 2012 and is available on the CNSC Web site. It included the following statement:

> The CNSC staff preparation for the mission was exemplary. During the review, the administrative and logistical support was excellent and the IRRS Team was extended full co-operation in technical discussions with CNSC personnel. The CNSC counterparts were enthusiastic and very interested in discussing their actions taken to address the previous findings and in identifying ways to move forward to further improve the regulatory and nuclear safety framework in Canada.

The follow-up mission report also noted the following strengths of Canada's nuclear regulatory system:

- The recommendations and suggestions from the initial IRRS mission in 2009 were systematically addressed through active senior management commitment.
- The regulatory response to Fukushima was prompt, robust and comprehensive.
- The regulatory framework for transport of radioactive materials is well established and commensurate with the large scope and volume of transport activities in Canada.

Regarding the recommendations and suggestions from the initial IRRS mission, the IRRS review team concluded that they "have been taken into account systematically by a comprehensive action plan. Significant progress has been made in many areas and many improvements were carried out following the implementation of the action plan." The follow-up mission concluded that 13 of 14 recommendations and 17 of 18 suggestions made during the initial IRRS mission had been effectively addressed and therefore could be considered closed. The one IRRS recommendation from 2009 that remains open – to implement periodic safety review (PSR) – is being systematically addressed by the CNSC (see subsection 14(i)(h)). The one IRRS suggestion from 2009 that remains open is not directly relevant to NPPs.

Regarding the response to Fukushima, the follow-up IRRS peer-review team concluded that the CNSC's regulatory response to Fukushima was prompt, robust and comprehensive and identified the following good practice (GPF4) that should be used by other regulatory bodies:

> The CNSC has performed a systematic and thorough review of the implications and the lessons learned from the Fukushima accident for the safety of the Canadian NPPs,

making full use of all the information available, including the review of the actions taken by other international nuclear regulators. The CNSC has set up an Action Plan for addressing all the findings and recommendations arising from the review conducted under the CNSC Fukushima Task Force. The Task Force Report has been made publicly available.

The findings from the follow-up IRRS mission related to CNSC's response to Fukushima and the CNSC's response to them, are also cited in boxes in this report (specifically in article 16).

The findings from the review of the transport module during the IRRS mission are outside the scope of this report and hence are not discussed further.

General description of the Harmonized Plan and other improvement initiatives

Many of the improvement initiatives needed to address the findings of peer reviews and other assessments of the CNSC are addressed through the CNSC's Harmonized Plan which is the CNSC's mechanism for planning, prioritizing, integrating, monitoring and disseminating the results of improvements in various areas. 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 helps CNSC managers work together to reduce duplication and redundancy. The Harmonized Plan is refreshed regularly to ensure it remains aligned with corporate priorities. The executive authority for the Harmonized Plan is the executive vice-president and chief regulatory operations officer (see subsection 8.1(b)).

The preparations for and execution of, the initial and follow-up IRRS missions were undertaken as projects under the Harmonized Plan.

The report of the initial IRRS mission in 2009 noted that 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."

Many Harmonized Plan improvement initiatives stem directly from the regulation of NPPs and will help improve the effectiveness and efficiency of the overall regulatory program 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 that define how the many contributors work together in a coordinated and well-managed manner
- improving information management in support of the regulatory program
- ensuring a consistent regulatory approach is applied for all licensees in a graded manner

Overall CNSC response to Fukushima

The CNSC fulfilled its post-Fukushima responsibilities at the national level by conducting a series of high-level activities. Briefly, the CNSC:

- activated its emergency operations centre and operated it continually for 23 days following the onset of the Fukushima accident to monitor the situation and contribute to the overall Canadian response

- issued a request to licensees, per subsection 12(2) of the *General Nuclear Safety and Control Regulations*, to provide information pertinent to Fukushima
- formed the CNSC Fukushima Task Force to coordinate the CNSC's assessment and response
- gathered information on international lessons learned and the CNSC's own provisions to prevent and manage an event similar to Fukushima
- developed criteria to help assess the licensees' information and the CNSC's provisions
- performed the assessment, identified findings, made recommendations and documented them in a report
- developed a detailed CNSC Action Plan*: Lessons Learned from the Fukushima Nuclear Accident* (the CNSC Action Plan for short) to address the recommendations
- consulted Canadians on both the initial Task Force report and the *Action Plan*
- requested the IRRS Fukushima review and established an External Advisory Committee (EAC) of independent experts to assess the CNSC's processes and responses in light of the lessons learned from Fukushima
- created an internal Fukushima Safety Improvement Implementation Team (FSIIT) to oversee the implementation of the CNSC Action Plan by NPP licensees

The effectiveness of the CNSC's early response measures can be summarized by the overall assessment of the EAC. The EAC concluded that the CNSC acted promptly and appropriately in the early stages of the Fukushima crisis and followed an appropriate process as it responded over time. The report complemented the findings of the CNSC Fukushima Task Force. It included nine recommendations that were accepted by the CNSC.

The EAC's recommendations can be sorted into three categories.

- application of Fukushima lessons learned to non-NPP facilities (outside the scope of this report)
- recommendations that align with actions already identified in the CNSC Action Plan, which are cross-referenced in this report
- communication and public education (see subsection 8.1 (f) for details)

For more information on the CNSC's overall response to Fukushima, see annex 8.

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, a quasi-judicial administrative tribunal comprising of a maximum of seven members. Commission members are chosen on the basis of their credentials and are independent of all political, governmental, special interest group or industry influences. 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 is designated as both the President and the Chief Executive Officer of the CNSC, as an organization.

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

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

CNSC staff regularly attend these Commission public hearings and meetings to advise, report and make recommendations to the Commission. Hearings and meetings are held to discuss, among other things, NPP status, licensees performance, overall industry performance and findings resulting from licensing and compliance activities, as well as to make licensing decisions. 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 can also retain the services of external persons having technical or specialized expertise to advise it, independently of CNSC staff. This provision is used as needed.

Suggestion S4 from initial IRRS mission in 2009

"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."

The CNSC implements external advisory bodies in appropriate situations. The peer-review team for the follow-up IRRS mission in 2011 noted that the CNSC had, in fact, used external advisory bodies twice since the initial IRRS mission in 2009. One example was the External Advisory Committee that provided the Commission with an independent assessment of the CNSC's actions in response to Fukushima and made recommendations for improvement. On that basis, the peer-review team closed suggestion S4.

For some technical issues, the CNSC has also jointly sponsored, with the NPP industry, independent technical panels to review certain aspects of the issues, such as the analysis of effects associated with the issue or the proposed methodology to address the issue. An example is provided in appendix G.3 of Canada's fifth national report, which describes an independent technical panel that reviewed a new neutron overpower analysis methodology to assess the slow loss-of-regulation event. This independent panel continued its advisory work in the more recent reporting period.

The Research and Support Program (described in subsection 8.1(d)) provides access to independent advice, expertise, experience, information and other resources via contracts and contributions placed in the private sector and with other agencies and organizations in Canada, as well as in other countries.

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

Funding

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

In the past, CNSC regulatory activities were fully funded through the appropriations from Parliament. During the previous reporting period, the Government of Canada granted the CNSC the authority to re-spend the revenue it collects to fund its regulatory activities. This authority provides the CNSC with more flexible, timely and sustainable funding to address fluctuations in activity associated with fee-paying licensees.

Revenue recovered from the fee-paying applicants and licensees in accordance with *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations* accounts for almost 70 percent of the CNSC's funding.

NPPs are fee-paying licensees that are charged Regulatory Activity Plan fees – one of the four types of regulatory fees that the CNSC charges to its licensees and applicants. Regulatory Activity Plan fees account for over 90% of the total fees collected from CNSC licensees.

Suggestion S2 from initial IRRS mission in 2009

"CNSC should review its arrangements to ensure that it can adequately recover its regulatory costs."

The peer-review team for the follow-up IRRS mission in 2011 noted that the introduction of the new Fixed Proportion Fee Allocation Model for cost recovery had greatly enhanced the recovery of regulatory costs. On that basis, the peer-review team closed suggestion S2.

CNSC activities that are not recovered through cost recovery fees are funded through annual appropriations from Parliament. This accounts for the remaining 30 percent of the CNSC's funding.

Certain organizations are exempt from cost recovery and are not charged licence fees. These include not-for-profit institutions such as schools, medical facilities and emergency services, as well as government departments or agencies that hold a licence for an abandoned, contaminated site (assuming the licensee did not create the contamination). In addition to the exempt organizations, the types of activities funded through the annual appropriations are activities that the CNSC is obliged to conduct and that have no direct benefit for individual licensees (e.g., activities related to non-proliferation, emergency preparedness, public information programs and maintenance of the NSCA and its associated regulations). For fluctuations associated with these licensees or activities, the CNSC can request additional funding from the Government of Canada (see the next subsection).

Position of the CNSC in the government structure

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 NRCan.

The Commission requires the involvement and support of the Minister for special initiatives, such as amendments to regulations and requests for funding of activities not funded under the *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations*. For example, when its workload increases for activities that have no direct benefit to individual licensees, the CNSC, with the support of its Minister, seeks incremental funding through the Government of Canada's annual budget process, or from the Treasury Board Management Reserve in the 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.

Although the CNSC is the clear regulatory authority with respect to nuclear safety in Canada, various other national organizations play important, complementary roles. Legislation is established to set the relevant requirements for other areas of jurisdiction that are also applicable to nuclear-related activities. Memoranda of understanding and working relationships are established between these organizations and the CNSC to ensure that nuclear regulation is effective and consistent, safety is not compromised, all responsibilities are borne by the appropriate body and no ambiguity or overlap exists. Examples of such areas of jurisdiction are emergency preparedness, transportation of dangerous goods, environmental protection and conventional health and safety. In particular, 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. NRCan 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. Another close partner is the Department of Foreign Affairs and International Trade Canada, with which the CNSC frequently works to ensure fulfillment of Canada's international commitments pursuant to bilateral and multilateral treaties, conventions and understandings.

In 2012, the *Canadian Environmental Assessment Act* (CEAA; see subsection 7.1(b)) was repealed and replaced by the CEAA (2012), which identified the CNSC as one of three responsible authorities for the purpose of conducting EAs. The CNSC now has responsibility for both the process and decision making under the CEAA (2012).

The Government of Canada operates the Major Projects Management Office 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 in order to commit those agencies to achieving 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.

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

The CNSC issues NPP operating licences for 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 R&D Crown corporation)
- NRCan
- Canadian universities
- hospitals and research institutions
- federal and provincial government departments

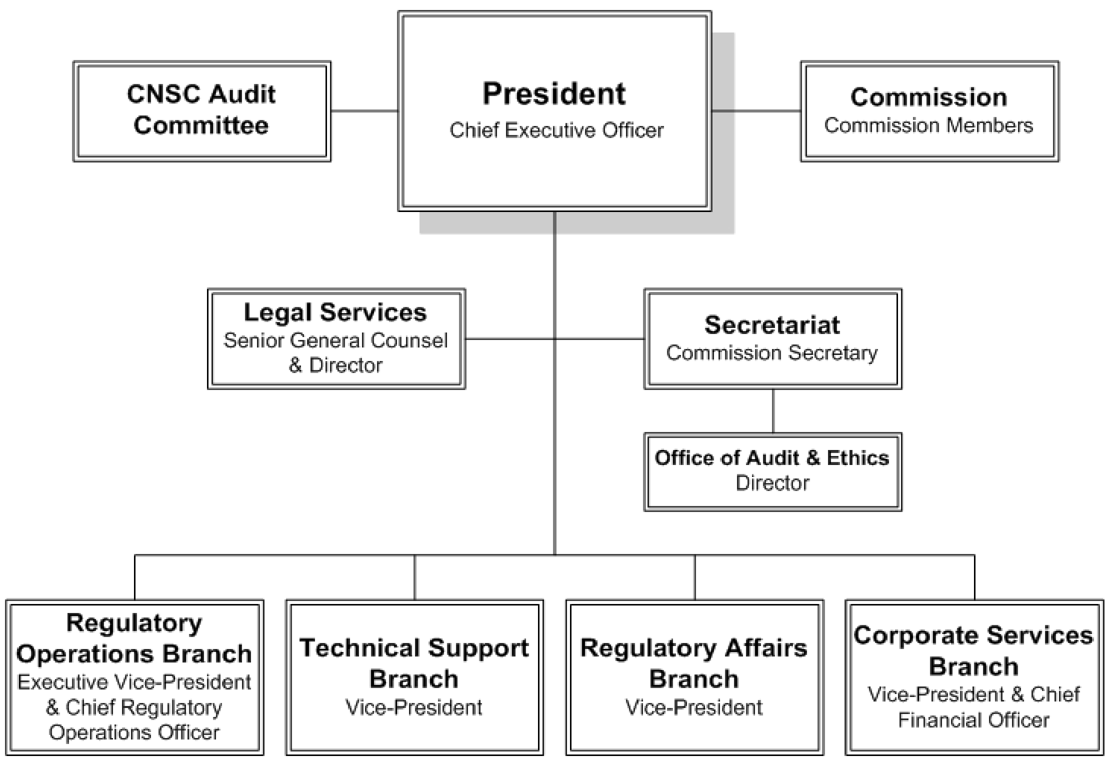
As part of its assessment of the lessons learned from Fukushima, the CNSC Fukushima Task Force evaluated the various organizations (including itself) that play significant roles in nuclear safety and nuclear emergency preparedness. In particular, the Task Force focused on the management of a nuclear emergency in Canada, which is a shared responsibility among municipal, provincial and federal jurisdictions. The Task Force reviewed the plans and capabilities of the relevant federal and provincial authorities with a view to identifying any outstanding issues related to coordinated nuclear emergency management. The CNSC Action Plan assigned actions to the CNSC to address, to the extent possible, some of the issues related to other national organizations involved in emergency preparedness. See subsection 16.1(a) for details.

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 Tribunal.

The CNSC's current organizational structure is described below.

Figure 8.1 (b) Organization of the CNSC



To satisfy the internal audit policy of the Government of Canada, the CNSC has an Audit Committee composed of three external members, the CNSC President and the Commission Secretary. The CNSC Audit Committee provides the President with independent and objective advice and assurance on how well the CNSC's internal audit and accountability processes are working. The committee's oversight also extends to areas and processes that include values and ethics, risk management, management control and accountability reporting.

The Commission Secretariat consists of the Secretary to the Commission and supporting staff. The Secretariat organizes all Commission hearings and meetings and provides the Commission with administrative and technical support.

The Office of Audit and Ethics, which is part of the Secretariat but whose work is also overseen and assessed by the CNSC Audit Committee, helps the CNSC achieve its objectives efficiently and in a way that demonstrates informed, ethical and accountable decision making. The Office of Audit and Ethics is responsible for independently and objectively assessing the adequacy and effectiveness of CNSC operations and for providing advice to CNSC management on related improvement initiatives.

The Office of Audit and Ethics also administers the CNSC programs for values and ethics, internal disclosure and conflict of interest and post-employment (see subsection 8.2(b) for additional description of the activities of the Office of Audit and Ethics).

Legal Services acts as counsel to the Commission in its statutory roles and provides legal representation in litigation and prosecution cases. It also provides advice and legal opinions to other CNSC staff members.

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

Regulatory Operations Branch

The Regulatory Operations Branch is responsible for managing regulatory activities, including those related to licensing, verification of compliance and enforcement. The relevant regulatory decisions may be made by Designated Offers, where the Commission formally assigns specific authorities to those officers in accordance with provisions set out in the NSCA and the regulations. It is headed by the Executive Vice-president and Chief Regulatory Operations Officer and comprises the following directorates:

- Directorate of Power Reactor Regulation
- Directorate of Nuclear Cycle and Facilities Regulation
- Directorate of Nuclear Substance Regulation
- Directorate of Regulatory Improvement and Major Projects Management

The Directorate of Power Reactor Regulation (DPRR) regulates the development and operation of NPPs in Canada, in accordance with the requirements of the NSCA and its associated regulations. Near the beginning of the reporting period, the divisions within DPRR were adjusted when the Planning and Reporting Division was absorbed into the Licensing Support Division. The directorate currently consists of the following divisions:

- four regulatory program divisions (RPD)
    - Pickering
    - Darlington
    - Gentilly-2/Point Lepreau
    - Bruce
- the Compliance Monitoring Division
- the Licensing Support Division

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

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

In addition to the site inspectors at the NPP, technical staff at head office are also assigned to each RPD.

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 (INES). The Compliance Monitoring Division also ensures consistency in compliance activities across NPP sites, identifies trends in compliance information, manages performance indicator data and conducts event investigations. During the reporting period, the Compliance Monitoring Division led the development of inspection guides and corresponding performance objectives and criteria for the set of compliance activities in the baseline compliance program (see subsection 7.2(iii)(b) for more details).

Suggestion S12 from initial IRRS mission in 2009

"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 peer-review team for the follow-up IRRS mission in 2011 noted that the time spent at an NPP site by the site inspectors has generally been limited by the typical, continual changing of the workforce and movement of employees within the CNSC. A large pool of technical specialist staff at headquarters participates regularly in inspections in various roles (see Technical Services Branch, below) and helps ensure commonality of inspection procedures, criteria and approaches across all NPP sites. The peer-review team also noted the effectiveness of other CNSC programs in place to "ensure the quality of inspector activities and inspector objectivity and independence" (e.g., multi-level supervision, work terms at other sites and headquarters, the role of the Compliance Monitoring Division, the Code of Ethics (see subsection 8.2 (b), the Conflict of Interest Policy and enhanced inspector training and qualification (see subsection 8.1 (c)). On that basis, the peer-review team closed suggestion S12.

The Licensing Support Division is responsible for DPRR projects, such as the licence improvement project, safe operating envelope and the possible implementation of periodic safety reviews (described in subsections 7.2(ii)(d) and 14(i)(h) respectively). The division is responsible for annual reporting to stakeholders on NPP safety performance and also manages CANDU safety issues (described in subsection 14(i)(j).

Within the DPRR, the consistency of the implementation of the regulatory programs across the NPPs is fostered by a common approach to training (see subsection 8.1(c)). Meetings are also held regularly to foster common understanding and consistent approaches among 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, contribute to the regulatory program for NPPs. The Directorate of Nuclear Cycle and Facilities Regulation is responsible, among other things, for various facilities associated with NPPs, such as uranium mines and refineries, conversion and fuel fabrication facilities and facilities for fuel waste storage and management of low and intermediate level waste. The Directorate of Nuclear Substance Regulation is responsible for some licences related to NPPs that fall outside the scope of the operating licence (e.g., licences for nuclear substances and radiation devices, transport, etc).

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

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

The responsibilities of the Internal Quality Management Division include the maintenance and updating of the Management System and the conduct and coordination of the Harmonized Plan. Among the responsibilities of the Regulatory Operations Coordination Division is the coordination of the annual operations planning process. These topics are 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. This division manages NPP vendor pre-project design reviews that provide vendors with regulatory guidance in regards to their NPP designs. It also participates in international activities that have a bearing on new-build projects, including those of the Multinational Design Evaluation Programme (MDEP). See the preamble to article 18 for more details on vendor pre-project design reviews and MDEP. This division plays a lead role in the preparations for new-build projects that are described in subsection 8.1(e).

Technical Support Branch

The Technical Support Branch consists of a large number of employees with particular knowledge and skills who provide technical support to the activities of the Regulatory Operations Branch, including DPRR and the Regulatory Affairs Branch. This is accomplished by providing specialist advice for regulatory programs, reviewing NPP licensee submissions, participating in inspections and helping to develop regulatory framework documents. Collaborations frequently include contributions involving several disciplines from across the Technical Support Branch and the Regulatory Operations Branch, requiring an integrated approach to resolving issues. The staff of the Technical Support Branch also shares scientific and technical information and experience with stakeholders in Canada and in other countries and undertakes special projects within their expertise and mandate.

The Technical Support Branch comprises 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 (DSS)

The Directorate of Assessment and Analysis has expertise in a wide variety of areas that include:

- safety analysis, including probabilistic safety assessment (PSA) and hazards analysis
- 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
- thermal-hydraulics, reactor system design and reactor system behaviour

The Directorate of Assessment and Analysis consists of eight divisions.

- Engineering Design Assessment Division
- Operational Engineering Assessment Division
- Probabilistic Safety Assessment and Reliability Division
- Systems Engineering Division
- Physics and Fuel Division
- Reactor Behaviour Division
- Reactor Themalhydraulics Division
- Assessment Integration Division

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

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

The Directorate of Environmental and Radiation Protection and Assessment has expertise in the areas of EA, 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 and co-operating and planning with other federal agencies, as well as provincial and international organizations (see article 16). It also has expertise in nuclear security, import/export of nuclear substances, equipment and devices; safeguards and non-proliferation and safeguards. The Directorate of Security and Safeguards consists of four divisions:

- Nuclear Security Division
- Emergency Management Programs Division
- Non-Proliferation and Export Control Division
- International Safeguards Division

During the reporting period, the staff in the DSS and DPRR helped enhance the integration of security- and safety-related issues in the CNSC's regulatory processes.

Suggestion S3 from initial IRRS mission in 2009

"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."

The peer-review team for the follow-up IRRS mission in 2011 noted that the CNSC had reviewed its fundamental "approach to discharging its mandate for safety and security and has introduced a more holistic and integrated approach...the organization as a whole is rising to the challenge of properly integrating security behaviour with safety behaviour to create a homogeneous safety culture within the CNSC." Procedures were revised to address the way security inspections are conducted and the roles and responsibilities of all CNSC staff. Security-related documentation sent to the Commission and to the licensees is now more widely reviewed. On that basis, the peer-review team closed suggestion S3.

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. The Strategic Planning Directorate is responsible for planning and reporting at the organizational level (e.g., reporting to Parliament), as well as evaluating the CNSC's effectiveness and efficiency in relation to its regulatory mandate. The Strategic Communications Directorate is responsible for both internal and external communications and hence contributes to measures related to openness and transparency.

Corporate Services Branch

The Corporate Services Branch provides general services necessary for the functioning of the rest of the CNSC. Such functions 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

Workforce management

Maintaining a skilled, knowledgeable and dedicated workforce is critical to the CNSC's success. 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 report of the initial IRRS mission in 2009 stated, as a particular strength of Canada, that "the recruiting process is facilitated by optimized employment conditions provided by the CNSC." The report also noted the benefits of the CNSC's authority to independently define its own employment conditions.

Following significant growth in the preceding years, the CNSC reached its optimal workforce levels in 2009–10. By the beginning of the reporting period, the CNSC had shifted its efforts from recruitment to retention. The current human resource priorities are to develop and retain talent, to sustain the CNSC's ability to attract a highly qualified workforce and to develop organizational flexibility.

During the reporting period, the CNSC assessed its anticipated workload and fee revenue in light of expected changes in the regulated nuclear industry. In particular, the announcement of the shutdown and decommissioning of Gentilly-2 (see subsection D.1 of chapter I) will result in a reduction of licence fees payable to the CNSC. This necessitates a commensurate reduction in staff at the regulatory and administrative levels. The CNSC is reducing its current staff complement of 850 by 40 full-time equivalent positions. The CNSC expects to manage these reductions by attrition and reassignment, therefore minimizing the need to lay off of existing employees.

The CNSC addresses potential succession issues by identifying critical positions that may be at risk due to potential retirements and by undertaking appropriate succession planning through recruitment and/or development. It has also formed working groups to characterize the workforce of the future in anticipation of potential scenarios.

Training

Each CNSC staff member has an individual learning plan that contributes to CNSC's strong learning culture by ensuring immediate and future learning needs are identified and to help CNSC meet its evolving business priorities and objectives.

The 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).

During the reporting period, the CNSC enhanced its Leadership Development Program, revamped the New Employee Orientation Program and continued the implementation of its Inspector Training and Qualification Program, as described in the following paragraphs.

The Leadership Development Program provides a focused approach for emerging and seasoned leaders to develop their leadership competencies and internal networks, creating a culture of collaborative managers who work effectively within the CNSC environment and are prepared to take on new challenges in the future. Group assessments based on the 360 degree concept were instituted during the reporting period to establish a baseline of the leadership profile at the CNSC, with a view to building organizational strengths and improving in key areas. To help guide employees in their self-directed learning, training roadmaps were developed for each level of management and for those exploring leadership roles. The proposed learning activities address key leadership competencies that help build an effective management cadre at the CNSC. A Leadership Fundamentals course is also available for all managers and their designated alternates.

The Orientation Program provides new scientific and administrative professionals with an understanding of the CNSC's vision, mission, structure, culture and values. It is designed to reinforce the CNSC as an "employer of choice", to promote long-term retention 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. A mandatory two-day orientation course provides a comprehensive overview of the NSCA, the regulated facilities and activities and the CNSC's current priorities.

The Inspector Training and Qualification Program 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 core training, service-line specific training and on-the-job training.

As part of the Inspector Training and Qualification Program, the DPRR developed a systematic approach for NPP-related knowledge and on-the-job-training for NPP site inspectors. This program includes a training plan that identifies the common inspector and specific training for NPP site inspectors, on-the-job training and evaluation manuals and a training qualification record that documents the inspector's progress. Each inspector is required to take courses related to the regulatory process, the CANDU design, non-technical topics (such as effective communications), radiation protection and conventional health and safety. An inspector card is issued only when the site supervisor at the NPP determines that the inspector-in-training has achieved all the training requirements. From the time a new inspector enters into the program, it takes approximately 18 months to obtain an inspector's card.

8.1 (d) Management System

The CNSC Management System presents an integrated, fit-for-purpose approach to managing the performance of mandated functions across the organization, linking people, processes and resources within the CNSC's overarching regulatory framework. The CNSC Management System is based on principles and requirements found within quality standards and internationally and nationally recognized models of organizational excellence. Senior CNSC management also specifies additional elements for the Management System, such as the CNSC's regulatory philosophy, strategic priorities, goal to become an employer of choice and the promotion and awareness of the CNSC's internal safety culture. 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 aligns to the IAEA document *The Management System for Facilities and Activities* (GS-R-3) and related safety standards. The CNSC actively participates in the ongoing development, validation and improvement of GS-R-3 and associated IAEA safety standards.

The CNSC Management System was the subject of extensive review during the initial and follow-up IRRS missions in 2009 and 2011, respectively. The relevant findings are discussed throughout this subsection. Leading up to these missions, the CNSC made significant progress in moving the organization from an expert-based system to a more process-based system.

Recommendation R12 from initial IRRS mission in 2009 "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." --- The peer-review team for the follow-up IRRS mission in 2011 concluded that "in substance CNSC has implemented what is required in GS-R-3 of a process based Management System that covers all activities of the organization. All the management processes, the core processes and the enabling processes are defined and described to some extent." The peer-review team also noted that ongoing integration and alignment of processes across the four branches of the CNSC were being carried out systematically through the Harmonized Plan. On that basis, the peer-review team closed recommendation R12.

The initial and follow-up IRRS peer-review teams also assessed the review process for the CNSC Management System. During the reporting period, the CNSC conducted several assessments of its Management System and practices, including the following:

- gap-analysis against IAEA GS-R-3
- assessment against the Government of Canada's Management Accountability Framework
- third-party review of the CNSC approach to Management System documentation
- comprehensive, third-party review of the CNSC Management System and its implementation status

The third-party (consultants) reviews resulted in a number of recommendations for improvement and further development of the Management System. All recommendations have been assessed by senior CNSC management and resulting actions have been addressed under the Harmonized Plan.

Recommendation R13 from initial IRRS mission in 2009 "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 peer-review team for the follow-up IRRS mission in 2011 noted the significant management system reviews that had already been undertaken and that the CNSC planned to conduct a full Management System review over a five-year period. The peer review-team closed recommendation R13 on the basis of progress and confidence.

During the reporting period, the CNSC undertook an external-party review to assess the documented approaches and methodologies of the Management System.

Under the CNSC Management System, the CNSC's documented approaches and methodologies for regulatory effectiveness have been further improved to better articulate a fit-for-purpose approach and clarify differences across process document types. Opportunities for improvements, as identified through self-assessments and any future initiatives needed for the improvement of the Management System will be implemented through the Harmonized Plan.

Management System Manual

The CNSC *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 itself.

The purpose of the *Management System Manual* is to describe for CNSC employees how the Management System integrates people, processes and resources within the CNSC's overarching regulatory framework in order 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 work instructions that guide staff and collectively provide details on how the 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.

Since the last update of the CNSC *Management System Manual*, in 2009, the CNSC has made considerable progress in defining key regulatory and administrative work processes that have enriched and strengthened the CNSC Management System. An update of the current CNSC *Management System Manual* is being drafted and anticipated for completion by the end of 2013.

Key procedures, processes and their review

During the reporting period, the CNSC developed, under the Harmonized Plan, a process and supporting documentation for the self-assessment of processes. The self-assessments are championed by the manager responsible for the process being assessed. The use of the process was piloted during the reporting period on the technical assessment processes used by the Directorate of Assessment and Analysis.

Suggestion S17 from initial IRRS mission in 2009

"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."

The peer-review team for the follow-up IRRS mission in 2011 noted the potential of the self-assessment process to aid the CNSC in the improvement of all Management System processes. Based on the progress demonstrated, the peer-review team closed suggestion S17.

The CNSC also developed mechanisms during the reporting period to gather information on the effectiveness of Management System processes. An evaluation of the CNSC's overall performance measurement framework was undertaken during this reporting period. Recommendations for improvement will be managed under the Harmonized Plan.

Recommendation R14 from initial IRRS mission in 2009

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

The peer-review team for the follow-up IRRS mission in 2011 noted that the CNSC had developed Intranet-based feedback mechanisms for staff to comment on management system processes. The team also noted that procedures were in place to forward the comments to responsible managers or other staff and to respond to the commenter. On that basis, the peer-review team closed recommendation R14.

The CNSC Office of Audit and Ethics (see subsection 8.1(b) and 8.2(b)) also conducts independent, internal audits of CNSC activities. The audits are done according to well established procedures including management of non-conformance. Annual audit reports, as well as reports on values and ethics, are submitted to the Office of the Comptroller General and the Treasury Board of Canada Secretariat and are posted on the external and internal Web sites.

CNSC staff work instructions 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 foster a consistent and transparent approach to the oversight of regulated facilities. CNSC staff work instructions are described in subsection 7.2(ii)(a) (for licensing) and subsection 14(i)(g) (for life extension).

During the reporting period, 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 its 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)

The CNSC risk-informed decision-making (RIDM) process, based on CSA document *Risk Management Guideline for Decision Makers* (Q850), is designed to systematically decide the best of course of action for addressing such matters as licensing issues and generic safety issues. RIDM is referenced in the CNSC *Management System Manual* and has been validated and successfully used by CNSC staff and management in several applications.

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

The RIDM process has been applied to several NPP licensing applications requiring regulatory decision. A more detailed description of the RIDM process and examples of its application are provided in appendix H. The report of the initial IRRS mission in 2009 commented positively on the "development [e.g., extensive RIDM training] and use [e.g., in developing risk profiles of licensees] by CNSC of processes and tools for risk informed decision making."

Planning process for regulatory activities

The overall plan for the CNSC is summarized in its annual Report on Plans and Priorities, which is presented to Parliament.

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 (see subsection 8.1(a)). The Regulatory Activity Plan, along with a notification containing the licence fee estimate, is sent to each licensee at the beginning of each fiscal year.

During the reporting period, the CNSC formally documented its annual operations planning process and improved high-level monitoring and reporting of resource usage in operations (actual versus planned), as well as some year-end regulatory activity reporting to licensees.

Suggestion S16 from initial IRRS mission in 2009

"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 peer-review team for the follow-up IRRS mission in 2011 noted that improvements had been made in the CNSC planning process (e.g., simplifying the process and starting earlier). The revised process had enhanced the integration of performance management information with resource usage. As a result of the introduction of the fixed proportion allocation model for calculating fees, changes in regulatory effort during the year (e.g., due to operational changes) no longer required immediate adjustments in the fee invoices to licensees. Instead, they can wait until the next fiscal year. On that basis, the peer-review team closed suggestion S16.

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 with 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. The CNSC Research and Support Program is independent of the extensive R&D program conducted by the industry. Appendix E describes the research objectives of the CNSC (and the Canadian nuclear industry) during the reporting period.

The report of the initial IRRS mission in 2009 noted the need for a more systematic alignment between the CNSC Research and Support Program and regulatory priorities. During the review period, the CNSC reviewed how it identifies, manages and controls its research-related requirements. This review led to a number of fundamental changes to the CNSC's arrangements, including the following:

- establishment of a new Regulatory Research and Evaluation Division within the Regulatory Affairs Branch
- review and prioritization of the short, medium and long-term research needs to support the CNSC's mandate
- alignment of research objectives to the CNSC's safety and control areas which facilitates the linkage between research and regulatory priorities
- creation of a single integrated research and safeguards support program plan which is developed on a three-year cycle
- use of established processes, controls and governance arrangements to oversee the program and proposed enhancements, including ongoing work to extend the program horizon to 10 years and longer

Recommendation R1 from initial IRRS mission in 2009
"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 peer-review team for the follow-up IRRS mission in 2011 noted that the CNSC's actions were being effective in defining and monitoring the short-term and long-term research programs. On that basis, the peer-review team closed recommendation R1.

Recommendation R2 from initial IRRS mission in 2009
"Sufficient resources for research activities should be allocated to support the outcome of the strategic planning programme."

The peer-review team for the follow-up IRRS mission in 2011 closed recommendation R2 based on progress and confidence that the commitment to the program developed in response to recommendation R1 would continue to ensure adequate resourcing.

8.1 (e) Readiness for new-build projects

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 projects (see subsection 7.2(i)(c)). It is noted that initiatives related to new-build preparations help inform the conduct of activities related to the existing operating facilities and vice versa.

During the reporting period, the CNSC implemented a comprehensive lifecycle project for new-build projects. Although tailored for the Darlington new-build project, it will provide the basis for a comprehensive lifecycle project plan for all licensing and compliance activities to be carried out for any future new-build reactor facility project. Phase II involves the characterization of all regulatory activities needed for the Darlington new-build project, from initial submission of the project description through the EA and turnover to commercial operation under a licence to operate. In conjunction with and closely tied to, this project are separate regulatory framework development support projects necessary to ensure clarity of CNSC expectations in specific technical and licensing areas (see subsection 7.2(i)(c)) as well as projects for the preparation of the necessary internal CNSC assessment plans and staff work instructions (see subsection 7.2(ii)(a)).

Suggestion S9 from initial IRRS mission in 2009

"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 peer-review team for the follow-up IRRS mission in 2011 noted that the lifecycle project is "being conducted using the existing processes, tools and governance arrangements in CNSC's Management System. In addition, resource planning information from the Life Cycle project is input into the CNSC's planning process." The peer-review team closed suggestion S9 on the basis of progress and confidence that the existing processes, tools and governance arrangements will continue to ensure that the lifecycle project will be appropriately controlled and resourced.

8.1 (f) Openness and transparency

Dissemination of information – general

Part of the CNSC's mandate is to disseminate scientific, technical and regulatory information to all stakeholders (see subsection 7.1(a)). 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 (see separate subsection, below)
- special interest groups (environmentalists, other non-governmental groups)
- residents of host communities and potential host communities
- other groups or individual members of the public

During the reporting period, the CNSC continued to identify and engage as many interested stakeholders as possible, focusing 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 areas of major facilities, media, provincial officials, professional associations and non-governmental organizations. The CNSC continued to maintain open lines of communication with a range of interested parties, including the Canadian Association of Nuclear Host Communities.

To ensure the needs of future stakeholders are met, the CNSC is proactively contacting communities likely to become involved in nuclear activities, such as waste repositories, 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 its regulatory framework. The organization has undertaken a variety of engagement activities, including the following.

- offering information sessions

- participating in the Certification and Training Advisory group (co-chaired by CNSC and the industry), involving policy-level discussions about the training and certification of NPP personnel
- participating in COG Nuclear Safety 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

Other initiatives undertaken by the CNSC to disseminate information are discussed n the separate subsection below on the response to Fukushima.

Open and transparent processes

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

The Commission conducts its business in an open and transparent manner. Public hearings and meetings, where possible, are held in communities affected by the decision at hand. All Commission hearings and meetings are open to the public and Webcast live for anyone to watch. They are announced well in advance and the agendas are posted on the CNSC Web site. Commission member documents (CMDs) are available to stakeholders upon request. Any stakeholder or member of the public may request the opportunity to intervene in a Commission hearing either in person on in writing. The Commission allows the use of teleconferencing and videoconferencing to facilitate public participation. As well, all transcripts of public Commission hearings and meetings are posted to the CNSC Web site after each hearing/meeting.

For the hearing associated with the EA and application for a licence to prepare a site for the Darlington new-build project, in addition to the above, the public was provided real-time access on the Web to all documents filed as well as an opportunity to comment (before the hearing) on all the filed submissions. Furthermore, a special public information session was held and Webcasted so that outstanding issues could be discussed in a public forum (also before the hearing). Members of the public were also provided, at the end of each hearing day, with the opportunity to take a few minutes to make their views known, even if they had not registered as intervenors and did not file written submissions.

The CNSC has significant opportunities for public involvement in its regulation making process (see subsection 7.2(i)(a)) and in its regulatory document writing process (see subsection 7.2(i)(b)). The introduction of CNSC discussion papers during the reporting period and the analysis and publication of the feedback they generate (see subsection 7.1) has also enhanced the degree and interactive nature of engagement possible.

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

In 2011, the CNSC established a participant funding program to give members of the public, Aboriginal groups and other stakeholders the opportunity to request funding to support their participation in the CNSC's regulatory decision-making process. This allows eligible stakeholders to participate in aspects of EA and/or a licensing action for major nuclear facilities. Funding may also be made available for other CNSC proceedings that are of significant interest to the public or to Aboriginal peoples. An independent Funding Review Committee, composed of three external members, reviews all funding applications and makes recommendations to the CNSC on potential funding recipients, individual amounts and deliverables. The CNSC approves the overall fund release.

During the reporting period, the CNSC introduced the practice of providing its annual *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants* for public comment. Comments that are submitted are read by the Commission and can be addressed, as necessary, at the public meeting when CNSC staff presents the report to the Commission.

The report of the initial IRRS mission in 2009 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."

Response to Fukushima

The CNSC used an extensive public consultation process to help ensure that other organizations, as well as Canadian citizens, had an opportunity to provide input into the CNSC's response to Fukushima. The major reports produced by the CNSC (e.g., the CNSC Task Force Report and Action Plan) were posted for comment by the public and the results and conclusions were presented to the Commission in a meeting that was open to the public. For further details, see annex 8.

The External Advisory Committee (EAC) acknowledged the early action taken by the CNSC. It and recommended that the CNSC develop a comprehensive communication and education strategy that includes tools such as social media and expands partnerships and relationships with various science media organizations with the ability to inform the public on nuclear safety. Following is a brief description of tools and strategies already used, as well as enhancements that will address this recommendation.

In February 2012, the CNSC launched its Facebook page in both French and English. This was followed, in January 2013, by the launch of a YouTube channel that features original CNSC video content. New content has been incorporated into the CNSC Web site to better cover all safety-significant aspects of the operation of nuclear facilities, including measures to deal with nuclear emergencies. The CNSC has already initiated regular updates on current topics of interest to the public and stakeholders, including the CNSC Action Plan and emergency preparedness. The CNSC Web site now features revamped Educational Resources on the nuclear fuel lifecycle, nuclear safety and other nuclear-related topics. The CNSC has also developed "CNSC Online", an interactive learning tool that provides information regarding the nuclear industry and the CNSC's role in regulating it. As a direct result of Fukushima, the CNSC has also developed a separate crisis Web site.

During the reporting period, the CNSC also initiated CNSC 101 Information Sessions, whereby CNSC staff go to Canadian communities to explain to stakeholders how the nuclear industry is regulated.

The CNSC worked with the Science Media Centre of Canada during the Fukushima crisis on the effectiveness of communication by its trained subject matter experts. In the next reporting period, more CNSC specialists will be trained to communicate with stakeholders, with an emphasis on crisis communications.

8.1 (g) Collaborative approach to resolution of safety issues

The Chief Nuclear Officer/CNSC Executive Forum provides an effective channel of high-level communication between the NPP licensees and the CNSC. The participants discuss strategic issues that involve both licensees and the CNSC, thereby promoting understanding and helping to focus action on safety issues related to NPPs. It is used to identify strategic challenges and opportunities that may influence the NPP 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 the following.

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

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

During the reporting period, the CNSC and NPP industry also created a strategic forum to discuss, on a quarterly basis, the progress in completing the CNSC Action Plan.

8.2 Status of the regulatory body

8.2 (a) Separation of the 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, such as the promotion of nuclear power.

The Commission (described in subsection 7.1(a)) is defined as a court of record in the NSCA, which allows it to conduct its matters in an independent manner. Commission members are subject to guidelines on conflict of interest and ethics that assure the separation between them and the various stakeholders. Commission members hold office "during good behaviour" rather than being appointed "at pleasure". This means that they can only be removed for cause. The Commission's decisions are not subject to review by any minister or other parts of the government executive. The NSCA provides that only the Governor in Council (Cabinet) 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. An example is the *Directive on Health of Canadians*, which is described in subsection 8.2(b).

To safeguard the integrity of the Commission's role as an independent decision maker, contact between the Commission and CNSC staff occurs through the Secretariat. With the exception of the Secretariat and the President, CNSC staff have limited interaction with the Commission outside of hearings.

The CNSC, as an organization, is also independent of other organizations in the government, as described in subsection 8.1(a). The independence of the CNSC from NRCan, which sets general nuclear policy for Canada, was assessed in detail during the initial IRRS mission in 2009. 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.

The follow-up IRRS mission in 2011 did not identify any new findings related to independence of the regulatory body, confirming that the CNSC continues to maintain an independent position relative to the community of organizations and persons that it regulates.

8.2 (b) Other mechanisms that facilitate regulatory independence

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

Guidance and structure for decision making

Nuclear 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.

General guidance to the CNSC was provided in 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 is necessary to protect the health of Canadians if a serious shortage of medical isotopes in Canada and around the world that puts the health of Canadians at risk.

The use of RIDM (described in subsection 8.1(d)) formalizes a decision-making process in which risk is considered systematically.

Office of Audit and Ethics

The Office of Audit and Ethics administers three ethics related programs. The Values and Ethics Program provides employees with guidance and techniques for strengthening relationships in the workplace and with stakeholders, as well as practical tools for ethical decision making. The Internal Disclosure Program is designed to help employees safely and constructively disclose wrongdoing and to protect them from reprisal. The Conflict of Interest and Post-employment Program gives the CNSC and employees tools to prevent and avoid situations that could create the appearance of conflicts of interest or result in a potential or actual conflict of interest.

A new *Values and Ethics Code for the Public Sector* was passed by the Parliament of Canada during the reporting period. This code 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 Values and Ethics Code* came into effect on July 1st, 2012. Following extensive consultations with management, staff and the union that represents the majority of staff members, the CNSC adopted six values ─ respect, integrity, service, excellence, responsibility, safety ─ complemented by expected behaviours that address the ethical risks that CNSC employees might face. A breach of both codes may result in disciplinary measures that extend to or include termination of employment. The *CNSC Values and Ethics Code* includes a Values and Ethics Agreement Form which 98 percent of CNSC employees have voluntarily signed, committing themselves, together with their supervisors, to the highest ethical standards and to speaking up when they observe unethical conduct.

Some 45 information sessions were provided to staff to explain the far reaching meaning of these values. The sessions covered the expanded *CNSC Conflict of Interest and Post-employment Policy* (2012) and the new *CNSC Directive on Reporting and Managing Financial Conflicts of Interest* (2012) which includes a List of Prohibited Securities. The CNSC external and intranet Web sites feature ethics-related legislation, policies, programs and procedures. Also posted on the Intranet are findings of disclosure reported by the Office of the Public Sector Integrity Commissioner of Canada, scenarios reflecting employees' ethical dilemmas, annual Values and Ethics reports and *Public Servants Disclosure Protection Act* reports. Guest speakers are invited to address staff during events and workshops are scheduled each fall and throughout the year.

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. As stated in subsection 7.2(ii), the Commission 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.

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

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.

For the most part, Canada has a relatively non-prescriptive nuclear regulatory regime for NPPs that sets general requirements and performance standards.

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

The Canadian regulatory approach allows the licensees some flexibility to meet fundamental safety requirements in a manner that best meets their needs. The licensees are responsible for addressing the requirements in their systems, programs, processes and designs. Descriptions of these provisions are submitted to the CNSC at the time of licence application (see appendix C). 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.

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

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

- compliance with regulatory requirements set out in applicable laws and regulations
- operating in accordance with the licensing basis (see article 19)
- defining and following operating policies and principles (OP&Ps; see "Specific organizational provisions" below)
- defining safe operating limits and working within them (see subsection 19(ii))
- developing safety policies and an organizational culture committed to ensuring safe NPP operation (see article 10)
- monitoring both employee and facility performance to ensure expectations are met (see subsections 12(h), 14(ii)(a) and 19(vii))
- ensuring that adequate qualified resources are always available to respond to planned activities and contingencies (see subsection 11.2(b))
- implementing managed systems to control risks associated with NPP operations to govern the above activities (see article 13)

As explained in subsection 13(a), all licensees are required in accordance with their operating licences to implement and maintain a management system in accordance with CSA standard *Management System Requirements for Nuclear Power Plants* (N286-05). An NPP management system is expected to establish safety as the paramount objective, foster the safe operation of the NPP during all phases of its life-cycle and implement practices that contribute to excellence in worker performance. CSA N286-05 requires various provisions that help ensure safe operation, such as ensuring worker competence, sharing and using OPEX, verifying the correctness of work, identifying and resolving problems and controlling changes. CSA N286-05 also requires independent assessments to confirm the effectiveness of the management system in achieving the expected results. These measures help ensure that the licensees' responsibility to safety is fulfilled.

General response of the licence holders to Fukushima

The licensees responded comprehensively to Fukushima, applying significant resources in a coordinated effort to systematically address the lessons learned. Following the accident, each licensee commenced detailed inspections and assessments, following the accident, to confirm the safety of the NPPs and identify areas for strengthening the response to severe/challenging events. The assessments met or exceeded the guidance and criteria provided by the CNSC and adapted to lessons that were gradually learned in the aftermath of the accident. Overall, the licensees responded in a timely fashion to the requests for information and action from the CNSC.

Specifically, the licensees proposed, or are evaluating, a number of further safety enhancements, such as additional coolant injection points, additional hydrogen mitigation and additional onsite and offsite power supplies and pumps (see subsection 18(i) for details). In addition, some NPPs have implemented modifications to improve defence against extreme natural events (notably flooding) and have accelerated the installation of passive autocatalytic hydrogen recombiners (PARs; see subsection 18(i) for details) and of severe accident management guidelines (SAMG; see subsection 19(iv) for details).

Specific organizational provisions

Many of the specific provisions used by each licensee to discharge its responsibility for safety are described in its OP&P document. This document is submitted in support of a licence application and is enforceable as part of the licensing basis of the NPP. The OP&P provide direction for operating the NPP safely and reflect a safety analysis that has been submitted to the CNSC as part of the licence application. For each NPP, the OP&P document explains how licensees operate, maintain and modify systems to maximize nuclear safety and keep consequential public risk acceptably low. Each licensee is required to define the bounds and limits for safe operation that are derived from the safety analysis used for obtaining the facility's operating licence. Operation in states not considered in, or bounded by, the safety analysis is not permitted.

Each licensee has appointed a key management leader who is responsible for the operation and safety of the NPP. These nuclear executives or nuclear officers also meet periodically at the Canadian Nuclear Utility Executive Forum, which is described below. Each licensee structures its organization in order to optimize the safety of the nuclear facilities under its responsibility.

The licensees also reviewed their organizations to identify potential changes in response to Fukushima. For example, at OPG, the security and emergency response organizations were amalgamated into one centre-led organization, under the leadership of one vice-president. The organization comprises resources from Fire Protection, Emergency Response, Emergency Preparedness, Emergency Management, Corporate Security and Nuclear Security, enhancing organizational accountability, efficiency and effectiveness through partnerships and collaboration. The Security and Emergency Services organization at OPG is committed to ensuring OPG can prepare for, respond to and recover from emergencies. The organization is focused on supporting operations while protecting its employees, assets and the communities in which it operates.

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

Peer and other reviews

The licensees conduct independent reviews that help confirm that their responsibilities for safety are being met. For example, the NPP licensees and AECL are members of the World Association of Nuclear Operators (WANO) and host WANO reviews on a regular basis (see subsection 14(i)(f). As another example, Bruce Power, OPG and NBPN initiate regular, independent, external, nuclear safety assessments through a Nuclear Safety Review Board (NSRB) to provide assurance that the requirements of their respective nuclear safety policies and nuclear management system are being fulfilled. The NSRB is a team of external industry experts that performs annual assessments (typically week-long) of NPP activities that might impact nuclear safety and performance. It reports directly to the Chief Nuclear Officer.

As follow-up to the alpha contamination incident at Bruce A Unit 1, Bruce Power initiated a review by the Radiation Safety Institute of Canada. Bruce Power acted upon the institute's recommendations and made its report available to the public. See annex 15(b) for details.

Collective measures

Although the regulatory framework 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.

In addition to membership in WANO and CSA, all NPP licensees in Canada and AECL are members of COG. COG is a not-for-profit organization dedicated to providing programs for co-operation, 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. In addition to its R&D program (described in appendix E.2, COG has the following initiatives and programs that facilitate the execution of licensee responsibility:

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

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

The Canadian Nuclear Utility Executive Forum, which includes senior representatives from all licensees and AECL, facilitates a coordinated approach to resolving significant technical and regulatory issues. 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).

In response to Fukushima, the NPP licensees established the CANDU Industry Integration Team (CIIT) consisting of representatives from domestic and offshore CANDU facility owners. The purpose of the CIIT is to ensure that Fukushima response activities are:

- coordinated and integrated in a manner such that the collective approach is consistent and aligned
- based on a common understanding of regulatory requirements
- bounded in scope and well managed

Within its mandate, the CIIT also initiated specific industry working groups through the auspices of COG to make progress on and resolve industry-wide technical, programmatic and R&D issues raised during Fukushima response activities. These include working groups for:

- emergency preparedness
- design modifications associated with Fukushima
- projects to address several of the SAMG-related findings from the CNSC Fukushima Task Force

Proactive disclosure and public communications

One of the CNSC's core priorities is to communicate clear information about nuclear activities in Canada and to ensure this information is easily available. In 2012, the CNSC published regulatory document *Public Information and Disclosure* (RD/GD-99.3), which requires NPP licensees to maintain public information and disclosure programs. The public information and disclosure programs must be supported by robust disclosure protocols regarding events and developments involving their facilities or activities. Program requirements are derived from the objectives of the Commission in the NSCA and the *Class 1 Nuclear Facilities Regulations*, which require a Class I licensee "to inform persons living in the vicinity of the site of the general nature and characteristics of the anticipated effects on the environment and the health and safety of persons that may result from the activity to be licensed." They also build on previously established guidance in CNSC guidance document *Licensee Public Information Programs* (G-217), which was published in 2004.

The following is a summary of required program elements in RD/GD 99.3:

- defining clear objectives and target audiences (e.g., residents, Aboriginal groups, elected representatives and government agencies, such as local police and fire departments)
- tracking public views, opinion and concerns
- developing strategies and products
- establishing and implementing a disclosure protocol
- maintaining documentation and records
- evaluating and improving the programs

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

By the end of 2013, RD/GD-99.3 will be added to all licences to operate NPPs.

The licensees were already implementing the majority of the requirements in RD/GD-99.3 before it was published. They have since been working on updating their public information programs, including improvements in the area of public disclosure, to meet the requirements of RD-99.3. The elements of a typical public information program are listed in annex 9(c).

The CNSC will verify compliance with the requirements on an ongoing basis, particularly with respect to the disclosures made under the protocols established by the licensees. Overall programs are evaluated annually and the results are published in the *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants*. The programs are also assessed during the review of an application to renew a licence to operate an NPP. Applicants are expected to describe how their programs build upon past activities and how they will be updated to address the communication needs of their target audiences during upcoming licensing periods. The programs are designed to correspond to the public's perception of risk and the level of public interest in the licensed activities.

In addition to the typical public information programs for existing NPPs, OPG continued to conduct a comprehensive outreach program related to the Darlington new-build project. The goal was to inform persons living in the vicinity of the site and those with an interest in the project, about events and developments at the site related to the project and to the future health, safety and security of persons and the environment, as well as any other issues associated with site preparation. Many activities were conducted during the reporting period. See annex 9(c) for details.

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

To assure compliance of the licensees with the various requirements, the CNSC:

- sets and documents clear requirements using a process that includes consultation
- co-operates 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 based on the level of risk
- 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).

Detailed requirements for the existing NPPs are established through the process to renew each licence to operate, which sets out the licensing basis for the facility. The renewal of operating licences reaffirms the responsibility of the licensees. The inclusion of new standards in the licences redefines the extent of that responsibility, relative to modern practices, on a regular basis.

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

Reporting requirements are an important aspect of the CNSC's assurance that licensees continue to meet their responsibilities. Operating licences refer to CNSC regulatory standard *Reporting Requirements for Operating Nuclear Power Plants* (S-99), which establishes reporting requirements for safety-significant developments and non-compliances 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 (e) Summary of fulfillment of safety responsibilities during reporting period

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

The licensees further fulfilled their responsibility to safety during the reporting period by executing numerous improvements to safety. Since original construction, the NPP licensees in Canada have made many safety improvements based on CNSC requirements, industry research, national and international operational experience and generally rising public expectations. In particular, licensees of those NPPs that have undergone refurbishment have performed a systematic review against modern standards, as part of the re-licensing process and have made modifications that reduce the likelihood and consequences of severe core damage and a large release of radioactive materials (see subsection 14(i)(g)). The licensees, along with the CNSC, sponsor R&D in various areas that contribute to safety improvements (see appendix E).

The NPP licensees conducted a prompt, thorough review of lessons learned from Fukushima. They responded individually to requests for information and assessment by the CNSC and formed the CIIT to coordinate their responses. The licensees’ work to address findings from their post-Fukushima assessment, as well as the CNSC Action Plan, has progressed well, with many activities already completed or on track for timely completion.

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

Part C
General Safety Considerations

Part C of chapter III consists of seven articles:

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

Article 10 – Priority to Safety

> Each Contracting Party shall take the appropriate steps to ensure that all organizations engaged in activities directly related to nuclear 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 to peer review and continuous improvement. For example, the NPP licensees regularly participate in WANO assessments (see subsection 14(i)(f). The licensees also demonstrate an ongoing commitment to safety through its sponsorship of and involvement in, safety-related R&D activities (see appendix E for details).

The CNSC has also demonstrated a commitment to peer review and improvement, including the hosting of Integrated Regulatory Review Service (IRRS) missions. As a follow-up to the initial IRRS mission in 2009, the CNSC hosted a mission during the reporting period that included a module related to the CNSC's response to Fukushima (see article 8). In addition, the President of the CNSC established an External Advisory Committee in 2011 to assess the organization's processes and response to Fukushima. A brief description of measures related to the prioritization of safety at the 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.

To ensure that licensees' policies and supporting processes give due priority to safety and in line with the holistic approach to consolidating common requirements in all QA programs and management systems, CNSC licensing requirements now refer to "management systems" and specifies CSA standard *Management system requirements for nuclear power plants* (N286-05) as the principal safety management requirement. A primary purpose of CSA N286-05 is to promote safe and reliable operation of NPPs through commitment and adherence to a set of management system principles. All NPP operating licences include CSA N286-05 as a requirement for management systems.

All licensees have implemented these 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). CNSC staff review 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 practice, Canadian NPP licensees have designed their management systems with a focus on safety as the overriding priority. Their management system processes ensure that conditions adverse to safety are systematically evaluated and resolved.

Corrective action programs are formalized to ensure issues affecting safety are addressed properly and promptly. These processes continue to mature each time they are used and the lessons learned are shared with the other licensees. See annex 13(a) for a description of the licensees' management system requirements.

Operability evaluations are completed when the ability of systems and components to carry out their safety-related function is uncertain. Decision-making processes are used to resolve significant problems that require prompt, coordinated response to indeterminate or known degraded conditions that impact on safety. 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. Senior management is ultimately responsible for the safety of the NPP and is, therefore, expected to develop processes to encourage and track the effectiveness of safety programs and to demonstrate through action that safety is of overriding concern. Supervisors' behaviour must also show that they expect their workers to follow safety processes, while at the same time encouraging a questioning attitude. At the individual level, the emphasis is on personal dedication and accountability for each individual engaged in an activity that affects the safety of the NPP. All employees are expected to be aware of and to adhere to, all procedures. This assures that rules, policies and regulations related to reactor safety, radiation safety, environmental protection, industrial safety, security, fire protection and other relevant areas addressed in the procedures, are followed. These expectations are promoted through training and leading by example; monitored through field observations, oversight committees and self-assessments and assured by means of coaching and mechanisms to encourage problem identification and effective corrective action.

Safety culture self-assessments

The NPPs conduct safety culture self-assessments, conduct follow-ups to identify safety culture issues, develop appropriate corrective actions and complete post-assessments.

The benefits of a safety culture assessment are the learning and improvement opportunities created. However, in a safety culture self-assessment there is 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 several 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 implementation of safety culture monitoring processes between safety culture assessments to identify possible subtle changes in safety culture
- the inclusion of safety culture as part of regular, third-party assessments by other industry organizations

The licensees use guidance from WANO, the Institute of Nuclear Power Operations and the Nuclear Energy Institute as their primary source of self-assessment requirements.

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 conducts a comprehensive nuclear safety culture self-assessment once every three years at each of its NPPs.

The assessment process continues to be 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, OPG staff are completing post assessment follow-ups of their actions to address the findings from the safety culture assessments.

OPG completed the following nuclear safety culture assessments during the reporting period.

Pickering A	2010
Darlington	2012
Pickering A and B	2012

Overall, the assessments at both Pickering and Darlington determined that each NPP has a healthy nuclear safety culture and respect for nuclear safety and that nuclear safety is not compromised by production priorities. Personnel feel they can challenge any decision if needed, without fear of professional or personal implications.

The need to improve change management and communication processes was identified in the recent nuclear safety culture assessments by OPG. This was expected as a result of recent business transformation (organizational restructuring) activities. Actions are underway to address these findings at each OPG site.

Hydro-Québec

In February 2012, a safety culture self-assessment was performed during an evaluation by peers at the Gentilly-2 NPP. This self-assessment demonstrated that Hydro-Québec staff understood the concept of safety culture. It also showed that management cultivates the promotion of the nuclear safety policy at the plant.

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

Bruce Power

Safety culture assessments were completed in 2009 and 2010 at Bruce B and Bruce A respectively. In 2011, however, Bruce Power identified a gap in its governance and implementation of the conduct of regular nuclear safety culture monitoring and assessment. As a result, in 2012, Bruce Power piloted an innovative nuclear safety culture monitoring process at each NPP and began to plan for a more standardized assessment methodology to complement the monitoring process.

As Canadian NPP licensees improve their understanding of nuclear safety culture drivers and how these can be assessed to offer insights to leadership, a more programmatic approach to safety culture continues to evolve. Techniques to assess and foster a healthy safety culture have been developed by the industry and adopted for use by licensees. The Nuclear Energy Institute developed a guideline that describes the industry's approach to assessing and addressing nuclear safety culture issues. This guideline has been adopted by most Canadian NPP licensees.

The Nuclear Energy Institute methodology relies on a Nuclear Safety Culture Monitoring Panel (NSCMP) to monitor process inputs that are indicative of the health of the organization's nuclear safety culture and to identify strengths and potential concerns that merit additional attention by the organization. Such panels have been formed at some Canadian NPPs. The goal of the NSCMP process is to enable an ongoing holistic, objective, transparent and safety-focused process, that uses all of the information available from a broad variety of sources to provide an early indication of potential subtle changes in nuclear safety culture. Inputs include the corrective action program, performance trends, CNSC inspections, industry evaluations, self-assessments, audits, OPEX, workforce issues and more. The NSCMP helps develop corrective actions and monitors their effectiveness. The NSCMP comprises seasoned nuclear professionals with broad, diverse backgrounds at NPPs. The panel, through its chairperson, reports to the site leadership team. Membership includes experienced professionals with responsibilities for the process inputs (e.g., site managers responsible for corrective action programs, nuclear oversight, employee concerns, self-assessments and regulatory compliance). The panel's major function consists of reviewing issues and trends that could impact nuclear safety culture health to ensure the issues are appropriately addressed. The process creates a forum in which leaders can gain insights into cultural drivers using a common language and framework.

Bruce Power established two NSCMPs – one for Bruce A and one for Bruce B. They meet three to four times per year to assess nuclear safety culture trends or potential issues and provide a report to the Bruce Power site leadership team. Senior leader engagement around improvements to nuclear safety culture monitoring and assessment processes was excellent, with an open, self-critical approach. Although the initial pilot NSCMPs and follow-up senior leadership reflection sessions only considered a small number of events, the approach provided an opportunity to further develop a common language around nuclear safety culture across the company. Although not statistically significant, results of the process provided an opportunity to address in an open forum insights around some of the nuclear safety culture drivers of past events.

The process was embraced and is being formally implemented in 2013 at Bruce A and Bruce B. The value of the NSCMP process is expected to improve through the year, with results for 2013 being shared early in 2014 with Bruce Power's NSRB when there is more confidence in the process and the resulting insights. Confidence will be further enhanced as a result of a baseline company-wide nuclear safety culture assessment planned for 2013, against which future NSCMP issues can be considered.

New Brunswick Power Nuclear (NBPN)

NBPN conducted a comprehensive nuclear safety culture assessment in March 2011. The assessment was carried out in two parts: a survey (with 77 percent response from NBPN employees and 27 percent response from contact staff) and an interview process conducted with 55 NBPN employees.

Enhancements to both the staff survey tool and the onsite assessment process have been made to facilitate the collection and consistency of assessment inputs.

One of the findings arising from the nuclear safety culture assessment was an erosion of attention to safety requirements. This erosion was attributed to a construction-versus-operational mindset as Point Lepreau was in a refurbishment outage. Restart plans included an emphasis on observation and coaching and field presence to address the issue. The Observation and Coaching program was widely considered a positive program that is helping to raise standards.

NBPN plans to conduct another safety culture survey in the next reporting period.

Atomic Energy of Canada Limited (AECL)

AECL has regularly monitored its safety culture through execution of quarterly surveys that poll a subset (approximately 25 percent per survey) of the staff. The four surveys have been analyzed for trends and high-level results were communicated to AECL staff, to the Safety Review Committee and to the Executive Committee. The survey results were also discussed with CNSC staff at a meeting in August 2012. Overall, the results point to improvement in the following:

- use of operating experience (move to a learning organization) as evidenced by an increase in positive responses to questions related to organizational learning
- better problem identification/resolution through a healthy reporting culture and improved conservative decision making
- improved standards of operation and equipment reliability through the recognition that nuclear risk is unique and requires constant examination

Additionally, a detailed safety culture assessment was executed between September and October 2012. It included a comprehensive questionnaire delivered electronically to all AECL staff; follow-up interviews with staff at CRL, Whiteshell Laboratories and Port Hope Area Initiative; and discussions with focus groups at all three sites. Results of this detailed assessment were compared with those of 2008,discussed with all managers in late November 2012 and communicated to all staff in December 2012. Improvements for CRL were noted in the following areas.

- use of OPEX, specifically in work planning, pre-job briefs and training
- procedure quality
- availability of safety equipment
- control of temporary changes
- improved operational standards

The surveys and the assessment have also indicated that additional effort is required to ensure that standards and expectations are established and clearly communicated to staff. Furthermore, supervisory oversight is needed to monitor work execution in the field in order to reinforce the desired behaviours.

Candu Energy Inc.

The safety culture expectations of AECL were transitioned to Candu Energy. Candu Energy has made safety both in the workplace and within technical activities a key commitment at all levels of the organization. Safety culture leadership training and usage of event-free tools are elements of the Candu Energy safety culture.

Future development

The Institute of Nuclear Power Operations (INPO) has recently revised its nuclear safety culture assessment terminology from 8 principles to 10 traits of a healthy nuclear safety culture. In response to this, the NPPs are now adopting these traits and focusing their assessments to align with each of the 10 areas which are as follows:

Individual commitment to safety

1. Personal accountability
2. Questioning attitude
3. Effective safety communication

Management commitment to safety

4. Leadership safety values and actions
5. Decision-making
6. Respectful work environment

Management systems

7. Continuous learning
8. Problem identification and resolution
9. Environment for raising concerns
10. Work processes

The paramount objective of every NPP is the safety of the operational reactors. To support safe operation, leaders define and implement practices that contribute to excellence in worker performance. Going forward, the licensees will continue to promote and reinforce those behaviours and actions most critical to supporting and maintaining a healthy nuclear safety culture.

10 (c) CNSC assessment of safety culture at the NPPs

The CNSC defines safety culture as:

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

This definition includes the degree to which a critical, questioning attitude exists that is directed toward facility improvement. CNSC research has shown that the characteristics of high-reliability organizations have been empirically demonstrated. That important milestone in the evolution of safety culture and its characteristics has become a particular focus of interest for the CNSC. The CNSC measures the organizational processes (such as roles and responsibilities, communications and training) that influence safety performance at Canadian nuclear facilities with the purpose of determining whether those organizations possess the characteristics of safety culture to ensure that they support the safe conduct of nuclear activities (see article 12 for more discussion on human factors technical review areas). The characteristics are as follows.

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

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

An applicant for an NPP licence is required by the *Class I Nuclear Facilities Regulations* to provide a detailed description of its operating organization. CSA standard *Management System Requirements for Nuclear Power Plants* (N286-05), which is cited in the licences to operate NPPs, includes several measures related to organizational changes. The CNSC, in its review, pays particular attention to the way that nuclear, radiological and conventional safety, as well as environmental protection responsibilities, are managed and integrated within the general management system.

CNSC staff use an organization and management review method to evaluate organizational influences on licensees' safety performance. The review method is a long-established, objective and systematic approach that has been used extensively to conduct baseline assessments of all operating NPPs in Canada. The review method, developed in collaboration with a research consultant, uses a multi-trait, multi-method approach to determine the presence or absence of organizational processes, or behaviours, that are important to safety. There are 17 behaviours that can be measured. Multiple data collection methods are used (e.g. surveys, interviews and work task observations) to measure each process. The results are then used to determine whether the licensee's organization possesses the characteristics of a culture where safety is its most important focus.

In previous reporting periods, the CNSC 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 were reviewed against the organizational behaviours that allow CNSC staff to observe emerging trends in the licensee's safety culture.

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

- documentation exists that describes the importance and role of safety in the operation of organization, such as a safety management program
- good housekeeping, material condition and working conditions are maintained
- use of continuous self-assessment is evident

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

The CNSC examines the self-assessment approach proposed by each licensee and reviews licensee plans to conduct specific assessments. The CNSC provides licensees with feedback on planned corrective actions that may arise from licensee self-assessments.

Safety culture discussion paper

The CNSC published a discussion paper entitled *Safety Culture for Nuclear Licensees* in August 2012. The discussion paper sets out the CNSC's overall strategy for safety culture in the Canadian nuclear industry, which comprising the following three components:

- formalizing the CNSC's commitment to promoting a healthy safety culture in the nuclear industry by providing a clear definition and describing the characteristics of a healthy safety culture so that stakeholders and the CNSC have a shared understanding of these concepts
- formalizing requirements and expectations for licensees regarding safety culture at all Class I facilities, waste facilities and uranium mines and mills
- clarifying and implementing the CNSC's oversight role and strategy to verify that licensees are conducting and implementing appropriate safety culture self-assessments and that corrective actions arising from these assessments are effectively implemented

Consultation on this discussion paper enabled the CNSC to engage with the industry, stakeholders and public on issues affecting safety culture. CNSC staff are currently analyzing and considering feedback on the discussion paper. In the next reporting period, CNSC staff will continue to develop a multi-pronged safety culture oversight strategy that may include reviews of licensees' self-assessments and corrective action plans, focused onsite assessments of safety culture, discussions and interaction with licensees at multiple levels, monitoring of safety culture through management systems and ongoing integration with other regulatory oversight activities.

The CNSC will also further encourage the NPP licensees to continue to develop and improve techniques to understand and foster a healthy safety culture and to monitor its evolution.

Another area under development is an approach to addressing nuclear safety culture in new-build projects. Although no new NPPs are 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 NPPs 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 addressed in the CNSC regulatory document *Licence Application Guide: Licence to Construct a Nuclear Power Plant* (RD/GD-369).

10 (d) 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 *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 on 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 their 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 regulatory decisions are made.

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 per article 9. This responsibility includes providing adequate financial resources to support the safety of each NPP throughout its life.

The *General Nuclear Safety and Control Regulations* require 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 that grant 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 maintain the decommissioning plans, cost estimates and financial guarantees and to report periodically to the CNSC that the costs remain valid, in effect and sufficient to meet the decommissioning needs. 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 not to 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 *National Report for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*.

Financing of the Pickering safe storage project

The financing of the placement of Pickering Units 2 and 3 in safe storage, while maintaining the systems and equipment needed to operate Units 1, 4, 5, 6, 7 and 8, was provided primarily by the Nuclear Decommissioning Fund.

The project scope and cost estimate for the placement of Pickering Units 1, 4, 5, 6, 7 and 8 into safe storage at the end of their operating lives are in development. The activities to transition the NPP into safe storage are planned to begin in approximately 2021 and be completed in approximately 2024. Some preliminary plans for the activities associated with the transition of Pickering NPP into safe storage were provided in the Pickering Sustainable Operations Plan. The first Stabilization Activity Plan which describes the steps to transition the NPP to safe storage, will be submitted by OPG to the CNSC in the next reporting period.

All licensees issue a Preliminary Decommissioning Plan every five years. The Preliminary Decommissioning Plan provides the long-term vision for the storage and surveillance period (approximately 30 years) prior to demolition and site restoration. In the Preliminary Decommissioning Plan, the estimated costs associated with decommissioning are presented.

Based on the decommissioning cost estimates provided in the Preliminary Decommissioning Plan, all licensees have provided assurance of adequate financial resources to complete decommissioning in a financial guarantee declaration.

11.1 (c) Nuclear Liability Act requirements

Subject to the *Nuclear Liability Act*:

> an operator is under a duty to secure that no injury to any other person or damage to any property of any other person is occasioned as a result of the fissionable or radioactive properties, or a combination of any of those properties with toxic, explosive or other hazardous properties, of
>
> (a) nuclear material that is in the nuclear installation of which he is the operator;
> (b) nuclear material that, having been in the nuclear installation of which he is the operator, has not subsequently been in a nuclear installation operated under lawful authority by any other person; or
> (c) nuclear material that is in the course of carriage from outside Canada to the nuclear installation of which he is the operator or is in a place of storage incidental to that carriage.

As required under subsection 15(1) of the Act:

> the operator shall, with respect to each nuclear installation of which he is the operator, maintain with an approved insurer insurance against the liability imposed upon him by this Act, consisting of
>
> (a) basic insurance for such term and for such amount not exceeding seventy-five million dollars as may be prescribed with respect to that nuclear installation by the Canadian Nuclear Safety Commission, with the approval of the Treasury Board of Canada, and
>
> (b) supplementary insurance for the same term and for an amount equal to the difference, if any, between the amount prescribed under paragraph (a) and seventy-five million dollars
>
> and containing such terms and conditions as are approved by the Minister.

Under current policies, the Nuclear Insurance Association of Canada and the European Liability Insurance for Nuclear Industry are approved providers of nuclear liability insurance in Canada. The term of these policies is typically one year, renewable every year unless amended or cancelled.

The Government of Canada has announced that it intends to bring forward new legislation in Parliament in the fall of 2013 that will update and enhance Canada’s nuclear liability regime, including increasing the liability limit for nuclear operators from $75 million to $1 billion. In concert with revisions to Canada’s domestic regime, the Government intends to put in place measures that would enable Canada to join the IAEA’s *Convention on Supplementary Compensation for Nuclear Damage*.

11.2 Adequacy of human resources

The *General Nuclear Safety and Control Regulations* require 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 mean 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. Normal activities include the ability to respond to the most resource-intensive conditions under all operating states.

Challenge C-2 for Canada from the Fifth Review Meeting
"Overcome potential HR shortages in energy sector due to refurbishment, new build"

During the reporting period, the human resource challenge identified at the Fifth Review Meeting was alleviated by various developments, including the following.

- the decision to close Gentilly-2
- completion of refurbishment projects at Bruce A and Point Lepreau
- the decision not to refurbish Pickering B
- longer than anticipated time taken by the Province of Ontario to decide on the potential new-build project at Darlington

The licensees have extensive and effective programs related to training, staffing, examination, workforce capacity evaluation, hiring, knowledge retention and R&D, as described in the following subsections. These, in conjunction with the above developments, have contributed to the effective management of human resources, in general, across the industry.

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

Licensee training programs

Given that licensees are responsible for the safe operation of their respective NPPs, 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 positions.

Training programs are established in accordance with the principles of a systematic approach to training which ensure that licensee staff members receive training pertinent to their positions. Departmental programs are routinely reviewed and training needs analytically identified to allow training courses to be revised or developed as necessary to guarantee that the training replicates the procedures and equipment used in the NPPs. Furthermore, training program evaluation processes and procedures are regularly applied to assess the effectiveness of the training programs that assure staff members remain competent in their relevant job functions. For example, OPG uses objectives and criteria for accreditation of training that were developed by INPO.

Another example of the measurement of training effectiveness is Bruce Power's use of the "Kirkpatrick" model of learning evaluation. To evaluate training development requirements, a training effectiveness evaluation worksheet is used to identify the issue driving the need for training and to determine specific training topics, the expected results and the preferred method to evaluate training effectiveness. There are a number of criteria to measure the effectiveness of the training. These could include: trainee knowledge evaluation (written exam), trainee performance evaluation (lab, on-the-job evaluation, etc), performance indicator reviews (i.e. human performance), focus area self-assessments, field observations, interviews, supplemented assessments (internal nuclear oversight, peer reviews) and others. These criteria are set up during the development of the training and will differ, depending on the expected results and behaviours that the training is designed to deliver.

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

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 continue to be 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. The training and qualification of supplemental workers ensures familiarity with nuclear-related practices such as human performance tools and the corrective action program. The programs to assess the competencies of the supplemental staff include the evaluation of the knowledge and skills necessary to conduct specific work at the NPPs.

Training programs consider the requirements for supplemental personnel (for example electrical, hoisting and rigging and pressure boundary) as well as personnel performing a contract management role. The training programs consider previous training and experience through the use of standard task evaluations (Electric Power Research Institute (EPRI) methodology) or apprentice-related certificates of qualification. Specialized training is provided in areas such as environmental qualification, foreign material exclusion, respiratory protection, human performance and radiation protection and they include industry-related OPEX.

Qualification and numbers of workers

Annex 11.2(a) provides the requirements for the qualification and numbers of workers at NPPs, including those related to certified staff.

The minimum staff complement is the identified number of staff with specific qualifications that must be present at the NPP 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.

The number and qualifications of staff necessary to meet the requirements of the NSCA, the regulations and the licence are specific to each NPP. The minimum staff complement is determined by a systematic analysis and demonstrated by an integrated validation exercise according to expectations set out in G-323. During the reporting period, all NPP licensees were either conducting the systematic analysis of the minimum staff complement or had progressed to demonstrating the adequacy of the minimum staff complement through validation exercises. These projects are expected to continue in the next reporting period.

It should be noted that the minimum staff complement is currently assessed against the licensee's ability to respond to the most resource-intensive scenarios, which include normal operations, anticipated operational occurrences and design-basis accidents. As part of the CNSC Action Plan, NPPs are required to evaluate existing plans and take steps to enhance their emergency response capability to various conditions that extend beyond the previously postulated design-basis accidents, such as an extended loss of all AC power. In short, licensees are required to evaluate the habitability of emergency control facilities, the roles and functions of staffing requirements beyond minimum staff complement, the emergency procedures and equipment that would be used to mitigate any beyond-design-basis accident. Given the nature of the potential enhancements, human performance will be considered in the assessment of the response to beyond-design-basis accidents.

Days-based maintenance

NPPs have been transitioning to a days-based maintenance approach to scheduling maintenance activities. The purpose of this transition is to allow for the scheduling of the majority of maintenance work during days and to take non-essential maintenance personnel and activities off shift. The potential benefits of days-based maintenance include the formation of specialized maintenance teams, less fatigue due to rotating shifts, reduced turnover and reduced potential for error.

A transition to days-based maintenance requires a thorough analysis of the minimum shift complement requirements for maintenance personnel in event response. OPG's analysis concluded that for Darlington, maintenance-specific skills are only required for event mitigation in a limited number of scenarios. Operations staff have been trained to fulfill the emergency response organization roles previously held by maintenance staff. Thus, scheduling the majority of maintenance work during days will have no impact on event response.

An analysis of the structure and staffing of the emergency response organization was also completed by OPG to take advantage of efficiencies gained with the recent implementation of automated gamma monitoring systems at source term and near-boundary locations. OPG has demonstrated through analysis and validation that it has sufficient qualified workers available at all times to ensure safe operation of the facility and to mitigate the consequences of any emergency situation.

CNSC staff are supportive of a move to a days-based maintenance organization and recognizes that the benefits noted above should improve NPP safety.

Transfer of responsibility for certification examinations of personnel from the CNSC to licensees

Since 2009, licensees have been independently administering the initial certification examinations of their shift personnel seeking CNSC certification according to the requirements of the regulatory document RD-204 *Certification of Persons Working at Nuclear Power Plants*, which is cited in the licences to operate the existing NPPs.

Assessment of licensee training programs

The 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 processes and procedures in the context of a systematic approach to training and review of training programs, as well as onsite evaluation and inspections of the training program products and material.

The licensee's performance with respect to personnel training, personnel certification, initial certification examination and requalification tests, under the "human performance management" safety and control 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 satisfactory performance this safety and control area. See appendix F for a full definition of the CNSC safety and control areas and the performance ratings of the licensees during the reporting period.

Suggestion S8 from initial IRRS mission in 2009

"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 peer-review team for the follow-up IRRS mission in 2011 noted that the CNSC already had in place a certification process for the appropriate licensee staff at NPPs. During the reporting period, the CNSC applied aspects of the certification process to other licensed facilities on a risk-informed basis. On that basis, the peer-review team closed suggestion S8.

11.2 (b) Capability maintenance at NPP sites

In 2011, Electricity Human Resources Canada (formerly the Electricity Sector Council) 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:

- The requirement for new skilled workers is 45,000 new skilled workers are needed over the next five years, which is almost half of the starting workforce and more than twice the number recruited in the last five years.
- Retirement continues to be a serious and impending issue.
- Forty percent of the current workforce is expected to retire over the next 10 years.
- Approximately 70 percent of employees are over 40 years old.
- Recruitment and retention continue to be a priority to address existing vacancies and upcoming retirements.
- Increasing the supply of trained graduates into the sector will require increased collaboration among industry, employers and educational institutions.

Expected increases in demand in electricity in provinces across Canada mean that provinces will be required to build significant new generation capacity over the next 20 years. The challenge for the electricity sector will be 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 anticipation of increasing industry HR requirements (e.g., due to refurbishments and possible 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

In addition to the staff at NPPs, AECL employs nearly 3000 scientists, engineers and support personnel at its Chalk River Laboratories, including 530 PhDs and master's degree holders. This is the single largest science and technology laboratory in Canada. A key part of AECL's mandate is to "develop highly qualified people with technical, operational and entrepreneurial skills for a competitive knowledge economy." As noted at the beginning of this article, the closure of Gentilly-2 and other decisions have significantly alleviated the magnitude of the HR challenge.

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 in place to prepare potential candidates to assume critical positions as employees retire. To address anticipated readiness gaps at senior levels, OPG initiated a program to accelerate the development of high-potential engineers through focused development planning and targeted learning events.

Candu Energy is also addressing this issue through a comprehensive resource management system that focuses on delivery of engineering services to NPP licensees, refurbishment of existing reactors and new reactors to be built. This functionally-managed system covers various groups in Candu Energy business units and takes an optimal approach to dealing with volatility of business, balancing customer needs and ensuring a consistent approach, while complying with its collective agreements and using best practices. System elements are grouped on the basis of supply, demand, resource planning, development of resources and performance management. Skills of individual technical staff are identified and maintained with succession plans established to meet the commercial demands of the business. The attrition risks of these employees are actively managed by a dedicated functional resource management team that continually assesses worker skills, knowledge and qualification to identify gaps and utilize a combination of targeted and on-the-job commercial training opportunities to close the gaps.

Hiring programs

NPP licensees continued to replenish their workforces through hiring programs to recruit workers into the operator, maintenance and engineering job-families. Recruitment of mechanical and control maintenance workers and operators is largely conducted through 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 (WiN) and North American Young Generation in Nuclear (NAYG), to promote the industry and increase the pool of potential applicants.

WiN-Canada was formed in early 2004 and emphasizes and supports the role that women can and do have in addressing the general public’s concerns about nuclear energy and the application of radiation and nuclear technology. WiN-Canada also works to provide an opportunity for women to succeed in the industry through initiatives such as mentoring, networking and personal development opportunities. NPP licensees and AECL have collaborated on a number of joint initiatives through a partnership with WiN. These include the production of a video, *The Catch* to encourage young women in high school to pursue a career in the nuclear industry, as well as an initiative to provide recommendations to the human resources electricity sector on how to develop more robust strategies to have women pursue trades careers in electricity.

A number of new graduate engineering trainees in the licensee organizations and AECL are part of the North American Young Generation in Nuclear (NAYGN). NAYGN provides opportunities for a young generation of nuclear enthusiasts to develop leadership and professional skills, create life-long connections and engage and inform the public.

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.

At Candu Energy, 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 Candu Energy or the licensee organizations. Further, Candu Energy recruitment utilizes social media and innovative partnerships with Canadian universities and Mitacs, a not-for-profit government-supported organization, to connect highly skilled graduate student and postdoctoral fellow interns and their supervising professors with CANDU technology projects aimed at addressing a clearly identified industry knowledge gap.

External training programs

The University of Ontario Institute of Technology (UOIT) has shaped a nuclear engineering program specifically to meet industry needs. The program has graduated over 200 bachelor-level students and over 45 masters-level students since 2007. There are currently 18 students in the PhD program. Close interface with industry members, the CSA Group and the CNSC is used to formulate the curriculum and select thesis and research topics at the university. UOIT generates graduate engineers from a full suite of engineering disciplines, including the Faculty of Energy Systems and Nuclear Science, which offers undergraduate (bachelor), master's and PhD degrees, graduate courses and graduate diploma programs in nuclear engineering, radiation science and related areas to support continuing education needs. The programs focus 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, brought together to support and develop nuclear education and R&D 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 by encouraging 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. Overall, the UNENE universities have approximately 130 students enrolled in work targeted at completion of either masters or PhD degrees. In 2011-2012, for example, 32 students graduated from the UNENE program with master's degrees and 5 with PhD degrees.

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

Knowledge retention programs

Knowledge management and retention continue to be important areas of focus for the NPP licensees. Various knowledge transfer initiatives are underway to mitigate the potential for critical knowledge loss due to the departure of a significant portion of the nuclear industry's knowledge workers.

For example, during the reporting period, OPG started the knowledge retention process with a pilot in one segment of nuclear engineering. The process focused on the critical positions, where knowledge loss is the greatest threat. The risk assessment of knowledge loss included establishing a rating based on the estimated time until retirement or departure and the position criticality to determine a total attrition factor. After the success of this pilot, it was extended to include all of nuclear engineering, and has continued to update staff risk tables and to implement knowledge retention plans. In addition, a knowledge management toolkit was developed to support managers in the further implementation of the process. Managers are periodically assessing the overall criticality of the roles and the availability of knowledge to the organization. The engineering leadership team fully supports the program and regularly reviews the knowledge assessment results.

Some of the initiatives to mitigate knowledge retention risks include the following.

- knowledge repositories that utilize common document retention software to increase knowledge retention
- staffing to achieve a mix of new graduate trainees, experienced hires and augmented staff to transfer knowledge
- establishing and refining partnerships with selected external service providers to provide a new means of implementing projects using the engineer-procure-construct (EPC) model
- mentoring and coaching staff and implementing an emergent talent process to accelerate the development of junior staff into more key roles in the business
- training through the use of on-the-job training and rotations to broaden the knowledge and experience of staff
- industry for a, designed for sharing best practices and discussing solutions to common issues and challenges (including an invited presentation at the recent U.S. NRC Regulatory Information Conference)
- centres of excellence, which establish a critical mass of expertise and a consistent fleet wide approach in key areas important to the business (for example, bringing together experts in component areas such as motors and valves)

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 R&D may be insufficient to sustain the core R&D elements of people and facilities. The nuclear industry recognizes that it is important to retain adequate core R&D capability, preserve expert knowledge and train future experts.

Every three years, COG produces a report on R&D capability in the Canadian nuclear industry. This report examines and documents Canadian R&D capability in order to ensure adequate financial resources for R&D, with the view of supporting continued safe and reliable operation of NPPs. The 2012 report assessed the impact of the R&D funding stream during the previous three years (2009–12) and of the resources anticipated for the following three years (2012–14).

The 2012 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 QA 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.

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 under the terms of their operating licences, which refer to CNSC document *Reporting Requirements for Operating Nuclear Power Plants* (S-99). The report of the initial IRRS mission in 2009 noted benefits of requiring the licensees to provide, on a regular schedule, reports of R&D activities (good practice G7).

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

Article 12 – Human Factors

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

Human factors are 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 or she works and the training he or 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* (P-119) describes how the CNSC considers human factors during its licensing, compliance and standards development activities. When determining if NPP licence applicants are qualified and if they have made adequate provision for health, safety and the environment, the CNSC will evaluate the extent to which the applicant has considered human factors and applied that knowledge, as well as the acceptability of the programs they plan to use for this purpose.

The CNSC has issued several regulatory documents and guides to assist licensees and licence applicants in the planning and implementation of human factors activities. In addition, a number of CNSC 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)

The CNSC addresses human and organizational factors throughout CNSC regulatory document *Licence Application Guide: Licence to Construct a Nuclear Power Plant* (RD/GD-369). It is necessary for the applicant to demonstrate the knowledge, skills and abilities of its workers and those of the vendor, major contractors and their subcontractors, as well as an overall commitment to fostering a healthy safety culture.

Human factors engineering (HFE) is the application of knowledge about human capabilities and limitations to plant, system and equipment design. HFE 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-build projects. HFE effort increases with higher levels of interface complexity or criticality and more HFE effort is typically required for operator tasks.

From a regulatory point of view, the CNSC expects that modern HFE principles and standards using best practices will be consulted when plant modifications are being considered, although it is recognized that the existing technologies, space limitations and control room practices may limit their application to older NPPs. The CNSC requires each licensee to indicate that modern principles and standards were considered and further explain how they are applied and why they may be inapplicable in specific instances and describe mitigating measures put in place to ensure safe long-term operation.

Elements of human factors are assessed and reported annually for all licensees in the *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants*. For example, several elements of human factors are reported under the “human performance management” safety and control area, whereas human factors in design are reported under the “physical design” safety and control area. During the reporting period, all licensees had satisfactory performance in the Human Performance Management safety and control area. See appendix F for a full definition of the CNSC safety and control areas and associated specific 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 projects as well as current operating facilities. In addition, issues related to human factors will be considered for NPPs that are approaching their end of life.

The CNSC subdivides its assessment of human and organizational factors 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. Human performance programs aim to minimize the potential for human error by addressing the range of factors that affect human performance. An effective human performance program integrates the full range of human-factors considerations across all organizational functions and activities – not just the people, but also the tools, equipment, tasks and environments in which they work – to ensure that people are fully supported in carrying out their work safely. 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 OPEX as opportunities to address problems before errors occur. Detailed reviews of operational conditions, activities, incidents and 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 assesses the organization's ability to create, integrate and implement defences that prevent or mitigate the consequences of human error in work activities. This includes a review of programs that detect latent organizational conditions and weaknesses, the ability to incorporate human and organizational factors into processes, performance monitoring metrics and strategies for improvement and the organization's overall commitment to fostering a healthy safety culture.

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 have evolved to different levels of maturity. Most recently, human performance programs have been interfacing with programs that detect and correct human error. Management is also more engaged in preventing human error by monitoring human-performance-related metrics. The focus, however, is largely on monitoring individual behaviours and the use of event-free tools such as adhering to procedures. The 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 are 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.

The requirement for a licensee to have a documented human performance program is being included as a licence condition in NPP operating licences as they are renewed.

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. The concept of 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, in order to ensure safe and reliable task and system performance and to minimize the potential for human error. The concept considers the cognitive, physical and sensory characteristics of people who operate, maintain or support the system, so that the systems and equipment are designed to support human performance.

As part of an ISR for a life extension project, licensees must determine the extent to which the current NPP and plant performance conform to modern standards and practices and identify any gaps (see subsection 14(i)(g) for details). During the reporting period, CNSC staff continued to work with licensees undergoing life extension projects, to ensure that the reviews against modern standards address expectations related to human factors that could limit safe long-term operation.

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 focus on ensuring that the process of incorporating human factors in design is implemented effectively by suitably trained, qualified and competent human-factors specialists.

The CNSC regulatory document *Design of New Nuclear Power Plant* (RD-337) includes requirements for addressing human factors in the design of new NPPs (see subsection 18 (iii) for details). CNSC regulatory document *Maintenance Programs for Nuclear Power Plants* (RD/GD-210) includes requirements for addressing human factors in maintenance.

12 (c) Human actions in safety analysis

Human actions are considered in probabilistic and deterministic safety analyses in order 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)(d).

Other safety analyses that consider human actions include hazard and operability studies, failure modes and effects analyses and hazard analyses.

Licensees use industry-accepted human reliability assessment methods within their PSAs to incorporate the probability of human errors in risk-important sequences. The CNSC does not require its licensees to use a particular method for human reliability analysis, but it verifies that the human reliability assessment method chosen meets the requirements of CNSC standard *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* (S-294) and that it is done in an industry-recognized and systematic way. One method frequently used is the technique for human error rate prediction. 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 have 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 and concise and they must contain adequate information and direction for the staff (e.g., operators, maintenance staff 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 focus 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 relate 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. They include, 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 NPP at all times to carry out the licensed activity safely and in accordance with the NSCA, the regulations and the licence. Aspects of human performance and human factors are considered in identifying the minimum shift complement. Staffing levels and minimum shift complement are discussed in more detail in subsection 11.2(a).

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 capable of performing the tasks of their assigned jobs within the required standards of safety, attendance, quality, efficiency and behaviour.

To ensure that workers possess the minimum requirements to perform their jobs safely and to minimize the risks to NPP safety, to the environment or of 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), which requires licensees to have a documented fitness for duty program for certified workers, CNSC staff initiated a project to further define requirements and applicability of fitness for duty programs. CNSC staff gathered information from comparable high-risk organizations, non-Canadian regulators and current NPP licensee programs relating to fitness for duty. During the reporting period, the CNSC published a discussion paper (DIS-12-03) on fitness for duty that focused on substance–related issues, titled *Fitness for Duty: Proposals for Strengthening Alcohol and Drug Policy, Programs and Testing*. CNSC staff are analyzing the many comments from various stakeholders and will ensure, in the next reporting period, that input is considered as part of the efforts to strengthen the regulatory requirements with respect to the breadth of fitness for duty requirements, the population of workers to be tested and the extent of alcohol and drug testing.

Fitness for duty requirements for nuclear security officers related to medical, physical and psychological fitness are covered by CNSC document *Nuclear Security Officer Medical, Physical and Psychological Fitness* (RD-363), which is cited in the licences to operate NPPs.

With respect to fatigue-related fitness for duty, the CNSC has expectations for limits on hours of work and mandatory rest periods between blocks of 12-hour shifts. These expectations are currently implemented by NPPs with some exceptions (e.g., application to casual construction trades and contractors, outages). The CNSC monitors hours of work violations, which are reported quarterly by the licensees. To strengthen the CNSC's regulatory framework addressing fatigue and hours of work, a regulatory document is being developed and will be released for public comment in 2013.

12 (g) Organizational performance

The CNSC review of organizational processes considers the influence of such processes as roles and responsibilities, communications and training 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 field where the operational work tasks are carried out.

The CNSC's review of licensees' organizational processes and performance is described in subsection 10(c).

12 (h) Performance monitoring and improvement

Performance monitoring and improvement applies throughout the entire lifecycle of a 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 OPEX 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 might have contributed to the event. Licensees have developed coding schemes to identify the causes of adverse conditions, which help ensure that the trending and identification of adverse conditions are effective. 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.

12 (j) Response to Fukushima – Human and Organizational Factors

The CNSC Action Plan identifies a number of actions that have implications for human and organizational performance. CNSC staff are reviewing the use of human and organizational tools, including task analysis, verification and validation, usability requirements, integrated system validation, procedure development, OPEX and lessons learned, habitability, equipment and instrumentation availability, severe accident management guideline (SAMG) development and validation, training needs analysis, and more.

In addition to identifying closure criteria for the actions and reviewing the submissions from licensees, CNSC staff are engaged in other multi-faceted deliverables to ensure that the safety of Canada’s nuclear facilities is enhanced in light of the lessons learned from Fukushima on human and organizational factors. These deliverables will focus on:

- ensuring the lessons on human and organizational factors learned from Fukushima are incorporated in the new and revised elements of the CNSC’s regulatory framework
- pursuing research to establish a better understanding of decision making in severe, unanticipated situations

Article 13 – Management Systems

> 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) Management system requirements

The *Class I Nuclear Facilities Regulations* require licence applicants to propose their quality assurance (QA) programs for the following activities to be licensed:

- site preparation
- construction
- operation
- decommissioning

The requirements for site preparation and construction also require the proposed QA program for the design of the nuclear facility. Applicants are required to provide descriptions of measures, policies, methods and procedures for worker health and safety protection, environmental protection, and for operating and maintaining the nuclear facility.

In line with the holistic approach to consolidating the common requirements in all quality assurance programs and management systems, CNSC licensing requirements now refer to "management systems" and specify CSA standard *Management System Requirements for Nuclear Power Plants* (N286-05) as the principal safety management requirement.

All NPP operating licences include CSA N286-05 as a licensing requirement for management systems. These management systems include processes for both the management of change and continuous improvement. As part of the management system, these processes are subject to regular monitoring and reporting to assess effectiveness and identify opportunities for improvement. See subsection 9(b) for additional description of management systems, as required by CSA N286-05. A more detailed description of a management system for an existing NPP is provided in annex 13(a).

The licence to prepare a site that was issued during the reporting period to OPG for the new-build project at the Darlington site (see subsection D.3 of chapter I) also cites CSA N286-05 as a requirement for management systems.

Licences for the activities to be licensed also include, directly or indirectly, the following QA / management system standards:

- CSA standard *Quality Assurance of Analytical, Scientific and Design Computer Programs for Nuclear Power Plants* (N286.7-99)
- International Standards Organization (ISO) document *Environmental management systems – Requirements with guidance for use* (14001-2004)
- American Society of Mechanical Engineers (ASME) document *Quality Assurance Requirements for Nuclear Facility Applications* (NQA-1)

13 (b) Assessment of licensees' management systems

The performance of licensees' management systems under the Management Systems safety and control area is assessed annually for all operating NPPs in the *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants.* These assessments include the following:

- Technical assessments: desktop reviews of licensees' management system documented information, such as policies, methods, procedures and records
- Type I Inspections: on-site assessments of the programmatic aspects of the management system's policies, methods, procedures and records
- Type II Inspections: on-site assessments of the outcomes of licensed activities

During the reporting period, the performance of all licensees was satisfactory. They have taken the appropriate steps to ensure that management systems are established and implemented. CNSC staff are confident that the specified requirements for all activities important to nuclear safety have been satisfied throughout the reporting period. 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 previous 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 of management system requirements

CNSC staff continue to participate in and promote the development of integrated management system requirements through the technical committees for CSA N286 and IAEA document *The Management System for Facilities and Activities* (GS-R-3). In 2012, the CSA Group issued *Management System Requirements for Nuclear Facilities and Activities* (N286-12). The standard, which included a name change, broadens its application from NPPs to include requirements for the following:

- uranium mines and mills
- uranium processing and fuel manufacturing facilities
- high-energy reactor facilities (nuclear power plants)
- research and isotope processing facilities
- radioactive waste management facilities

CSA N286-12 is an evolution of CSA N286-05 in that it now:

- better integrates the requirements from management system standards for health, safety, environment, security, economics and quality
- provides overall direction to management to develop and implement sound management practices and controls
- permits and recommends that organizations develop a single management system that integrates all management system requirements for health, safety, security, economics and quality (including quality assurance)
- applies across all lifecycle phase activities and allows for a graded approach commensurate with risk
- introduces a new principle: safety is the paramount consideration - guiding decisions and actions and supported by requirements
- introduces the promotion of a safety culture for the first time

- is in line with the international trend in standards to move to towards a more holistic approach to management, with the focus on providing direction to top management for creating purpose and commitment, capability, process definition and control performance monitoring and continual improvement, involving standards such as:
    - IAEA GS-R-3 for leadership and management for safety
    - British Standards Institution (BS) document PAS-99:2012 for common management system requirements
    - ISO 22301:2012 for business continuity
- provides broad technical correspondence with ISO14001:2004 (cited in CNSC regulatory document S-296) for environmental management and ASME NQA-1 (cited in ASME NCA-4000 which is itself cited in CSA standard *General Requirements for Pressure Retaining Systems and Components in CANDU Nuclear Power Plants* (N285.0) for pressure-retaining systems and components (both S-296 and N285.0 are cited in the existing licences to operate NPPs)
- provides broad technical correspondence with BS 18001 for occupational health and safety management – adopted by some NPP licensees
- supports 42 other CSA nuclear standards providing requirements and guidance for specific technical areas that support the management system

The CNSC will gradually introduce CSA N286-12 into the appropriate licences. CNSC staff will consult licensees and licence applicants to ensure a common understanding of the standard and the CNSC’s expectations for the transition from the -05 edition to the -12 edition.

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

14 (i) (a) General safety assessment in response to Fukushima

Canada's assessment of safety in response to Fukushima included comprehensive efforts from the CNSC, NPP licensees and other members of the nuclear industry. The overall CNSC approach to the assessment of safety post-Fukushima is described in the preamble of article 8, and the overall approach of the NPP licensees is described in article 9. Although much of the safety assessment was conducted by the licensees and reviewed by the CNSC, the CNSC also conducted its own assessment, which included specific reviews and studies, including the assessment of the CNSC's own regulatory framework and processes. Specific conclusions of the CNSC Fukushima Task Force and resulting actions that are related to the topics of safety assessment are cited in various subsections of this article.

In general, Canada's post-Fukushima safety assessment confirmed that operating procedures and equipment are in place at all CANDU reactors to ensure that the key safety functions are carried out for extended durations and to bring a reactor to a safe, stable state following an accident. The assessment also confirmed the general adequacy of the licensees' safety cases for external events. Specific details are provided in subsections 14(i)(c) and 14(i)(d).

The post-Fukushima safety assessment found that the licensees' assessment of the progression of beyond-design-basis accidents were adequate. The assessment, in combination with the detailed analyses of specific design provisions (described in subsection 18(i)), helped support the conclusion that the risk to the public from beyond-design-basis accidents and events at Canadian NPPs is very low.

The CNSC Fukushima Task Force noted that, for NPPs that had conducted integrated safety reviews (ISRs; see subsection 14(i)(g)) and identified vulnerabilities related to external events, modifications had been performed such that the refurbished NPPs now exceed or approach modern standards. The Task Force further recommended, however, that the licensees should conduct more comprehensive assessments of site-specific external hazards. The CNSC Action Plan assigned an action to licensees to complete the review of the basis of each external event to which the NPP may be susceptible using modern, state-of-the-art practices.

The licensees' work to address this action is described in the following subsections:

- reviews of the bases of external events – subsection 17(iii)
- updates to PSAs – subsection 14(i)(d)
- deterministic analyses for representative severe core damage accidents to confirm that consequences of events triggered by external hazards are within applicable limits - subsection 14(i)(c)

See Canada's report for the Second Extraordinary Meeting of the CNS for more details.

14 (i) (b) Assessment of licence applications

CNSC staff perform detailed assessments of safety in relation to NPP licence applications. Subsection 7.2(ii) describes the general CNSC licensing process for both new-build projects and currently operating NPPs and provides specific information related to CNSC licences to site, construct and operate an NPP. The CNSC's assessment of safety for a licence application is conducted against the application requirements in the *General Nuclear Safety and Control Regulations* and the *Class I Nuclear Facilities Regulations*. CNSC application guides have been written, or are in production, to supplement the regulations. They are written in the context of the 14 CNSC safety and control areas, which are described in appendix F. Further information on the application requirements and the guides is provided in subsection 7.2(ii).

CNSC staff use assessment plans, along with staff work instructions, to coordinate the assessment of licence applications related to NPPs. During the reporting period, the CNSC continued to develop a comprehensive set of technical assessment criteria matrices to aid these assessments (see subsection 7.2(ii)(a) for more details).

The rest of this subsection describes the CNSC's assessment of an application to renew a licence to operate an NPP. These assessments typically recur every five years for currently operating NPPs in Canada, corresponding to the typical duration of a licence to operate. The other type of major NPP licence application assessment relevant to the reporting period – that of a licence for siting a new NPP – is described in article 17.

In accordance with the regulations and CNSC guidance, an application to renew a licence to operate an NPP typically addresses the programs and plans listed in appendix C, which are aligned with CNSC safety and control areas. The CNSC conducts a balanced assessment of the licensee's programs and activities, with priority placed on certain areas based on performance history, risk and expert judgment. CNSC staff focus on the following elements:

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

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

[4] These ratings are, in fact, produced for all licensees and all safety and control areas on an annual basis, as described in subsection 14(i)(e).

The assessment of the application to renew the licence to operate can be illustrated by the following major results of the CNSC assessment for the renewal in 2011 of the licence to operate Point Lepreau:

- The safety and control areas for Point Lepreau were all rated as “satisfactory”.
- The design modifications and enhancements completed during the refurbishment outage met the modern safety goals established for NPPs undergoing life extension and addressed the required short- and long-term measures to address Fukushima-type events.
- A site-specific seismic hazard assessment was requested.
- The implementation of the severe accident management (SAM) program was assessed to be adequate.
- The need for improvements in aging management was noted.

Since the renewal, Point Lepreau has made various improvements to its aging management programs.

14 (i) (c) Deterministic safety analysis

General Requirements

General requirements for deterministic safety analysis are found in the *Class I Nuclear Facilities Regulations*. Paragraph 5(f) of those regulations requires an applicant for a construction licence to submit a preliminary safety analysis report. 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

For new-build projects, CNSC regulatory document *Design of New Nuclear Power Plants* (RD-337) stipulates that the preliminary safety analysis report must include the deterministic safety analysis, a PSA (discussed in subsection 14(i)(d)) and a hazards analysis.

Under paragraphs 6(a) and 6(b) of the *Class I Nuclear Facilities Regulations*, an application for a licence to operate a Class I facility shall contain descriptions of the systems, structures and equipment of the facility, including their design and design operating conditions. Paragraph 6(c) further requires the application to contain a final safety analysis report demonstrating the adequacy of the design of the facility. Details on the content of a typical safety analysis report for a currently operating NPP are provided in annex 14(i)(c).

The licensees use integral mechanistic models to simulate accident progression. 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 noted above, the licensees are subject to the 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. The NPP licensees have established specific validation programs in accordance with CSA N286.7 for industry standard tool (safety analysis) codes to provide the necessary confidence in the analytical results. During the reporting period, the industry continued to make progress on extending the validation of these codes to all applications.[5]

To meet the operating licence requirement that cites CNSC document *Reporting Requirements for Operating Nuclear Power Plants* (S-99), the NPP licensees, within three years of the date of the last submission of the NPP description and final safety analysis report, must submit an updated NPP description and an updated final safety analysis that include:

- a description of the changes made to the site and the NPP's SSCs, including any changes to the design and design operating conditions of the SSCs
- safety analyses that have been appropriately reviewed and revised and that take account of 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

Examples of safety analyses that were updated during the reporting period are provided in the subsection below titled "Updating safety analysis methods and acceptance criteria". During the reporting period, CNSC staff reviews of the safety analysis reports confirmed that the safety margins for all Canadian NPPs remained acceptable.

The licensees' safety analysis programs address the management of beyond-design-basis accidents and severe accidents. In this context, a beyond-design-basis accident refers to a relatively low-frequency event sequence that is not included in the NPP design-basis (due to the low frequency of occurrence) and that is not bounded by analysis of the NPP design-basis. If the safety consequences of such events are significant (e.g., with core and/or fuel damage and the potential to exceed the regulatory dose limits), these accidents are referred to as severe accidents. A typical safety analysis report for an existing Canadian NPP does not include a specific section devoted to the analysis of beyond-design-basis accidents. However, NPP licensees are using deterministic severe accident analyses to help develop computational aids and procedures, identify potential strategies for mitigating severe accident consequences, train staff and conduct validation exercises. The assessment of beyond-design-basis accidents using PSA is discussed in subsection 14(i)(d).

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

[5] The validation of data, models and codes used in accident analysis has been identified as a Category 3 CANDU Safety Issue; see subsection 14 (i) (j) and, specifically, subsection G.3 of appendix G for more information.

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 initial 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, reflecting 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.

The safety report for Darlington continues to reflect the requirements of CNSC consultative regulatory document C-006.

Updating safety analysis methods and acceptance criteria

During the reporting period, the CNSC continued to update the regulatory framework for NPPs, as described in subsections 7.2(i)(b) and 7.2(i)(c). CNSC documents that contain updated requirements related to safety analysis include the following:

- *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; see subsection 7.2(ii)(d))
- *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 projects and their adaptation to existing NPPs

The licensees' work to update their safety analyses and safety analysis reports, such that they will be aligned with the new documents, is ongoing. The implementation for operating NPPs consists of a gap assessment to prioritize analysis activities, in order to address identified gaps and shortcomings. The most significant issues are addressed on a priority basis. In the longer term, compliance with these documents, to the extent practicable, will be achieved as part of

NPP refurbishment plans. For licensees undertaking life extension, CNSC document *Life Extension of Nuclear Power Plants* (RD-360) requires the safety analysis update to be completed to according modern standards for a post-refurbished NPP.

The new regulatory framework for safety analysis and criteria, which is based on RD-337 and RD-310, represents a change in the Canadian approach. As described above, unlikely combinations of events, such as a large-break loss-of-coolant accident (LBLOCA) combined with unavailability of a special safety system, have historically been treated as design-basis accidents in the Canadian regulatory framework but (typically) as beyond-design-basis accidents in other jurisdictions. The new Canadian approach allows reclassification of these types of events to beyond-design-basis accidents and involves analysis to demonstrate meeting of the quantitative safety goals associated with PSA (as per RD-337).

The key new document related to safety analysis is RD-310, which is aligned with international standards on safety analysis. Its purpose is to update and improve transparency and consistency of safety analysis activities supporting the safe operation of Canadian NPPs. RD-310 identifies high-level regulatory requirements for an NPP licence applicant's preparation and presentation of deterministic safety analysis in the evaluation of event consequences. RD-310 requires beyond-design-basis accidents to be adequately addressed.

All future new-build projects will be expected to be fully compliant with RD-310. For existing NPPs, the implementation of RD-310 is being phased in over a number of years. The document is being added to operating licences as they are renewed, and implementation plans are being added to the respective LCHs. Assessments of the gaps between the requirements of RD-310 and the existing safety reports are being used to prioritize the safety report updates. Although it is recognized that the existing safety cases are not in question, the safety margins and degree of conservatism in the analyses need to be confirmed.

To better coordinate safety report updates across the industry, the NPP licensees established a safety analysis improvement program through COG. The NPP industry and the CNSC participate in a working group to address specific safety analysis shortcomings identified by the CNSC as well as other safety analysis issues important to the industry. One of the purposes of the COG safety analysis improvement program is to facilitate the implementation of RD-310. Specific areas of focus in the program include assessing 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 guidelines document for safety analysis
- pilot studies of Darlington loss-of-reactivity control, Bruce A loss of flow and Point Lepreau safety report dose assessment
- gap assessments for the set of analyses in the safety analysis report, followed by the necessary actions to address such gaps
- overall improvement of the safety analysis report

The activities undertaken in the safety analysis improvement program are chosen, in part, to address the CANDU safety issues described in subsection 14(i)(j). For example, the pilot study of the Darlington loss of reactivity control, mentioned above, addressed one of the non-LBLOCA Category-3 CANDU safety issues. In that work, OPG integrated modern, validated, coupled thermal hydraulic and reactor physics tools and classified events into the categories of anticipated operational occurrences, design-basis accidents and beyond-design-basis accidents.

The lessons learned from the pilot studies are being used to update a COG document that provides guidance for deterministic safety analysis and, in particular, for the implementation of RD-310. Additional analyses to extend compliance with RD-310 will continue in the next reporting period.

In addition to completing the pilot studies related to RD-310, the licensees conducted other updates of their safety analyses and safety reports during the reporting period and submitted them to the CNSC for review, as appropriate. Examples of updates to deterministic safety analyses that were conducted during the reporting period are provided in annex 14(i)(c).

Response to Fukushima – Deterministic safety analysis

As part of the overall approach to the post-Fukushima safety assessment described in subsection 14(i)(a), the licensees and CNSC Fukushima Task Force reviewed the deterministic safety analyses for each NPP. The assessment confirmed that the safety analysis of each NPP adequately considers design-basis accidents and meets or exceeds the original design intent. The safety report of each NPP shows that the predicted consequences, with conservative safety analysis assumptions, meet the CNSC's prescribed acceptance criteria. In particular, the analyses address credible failures in process and safety systems that could result in challenges to fuel cooling in the reactor core and irradiated fuel bays.

As noted in subsection 14(i)(a), the CNSC Fukushima Task Force found that the licensees' assessment of beyond-design-basis events were adequate. In response to Fukushima, the licensees developed a sequence based on a prolonged loss of electrical power leading to a loss of all heat sinks and, inevitably, core disassembly. This was not assumed to be initiated by any particular external event; rather, it was simply assumed that electrical supplies to power primary and secondary heat sinks were not available, regardless of the improbability of such an event. In summary, assuming that the operator takes very simple actions during the sequence to use the steam generators as a heat sink (e.g., use of the boiler emergency cooling system or de-aerator supply), at least 17 hours, and up to several days, will elapse before core disassembly. Connection of temporary power and additional water supplies can extend this period indefinitely. Further details are provided in Canada's report for the Second Extraordinary Meeting of the CNS.

In response to Fukushima, the NPP licensees have performed or are planning to perform deterministic analyses for representative severe core damage accidents. Such safety analysis has already been conducted as part of the ISR to decide on the scope of refurbishment activity for NPPs undergoing life extension. The licensees are enhancing their models for beyond-design-basis accidents to specifically address multi-unit events.

Fire safety assessment

Each facility has revised its fire safety assessments (code compliance review, revision to the facility's fire hazard assessment, and fire safe shutdown analysis) in accordance with the CSA standard *Fire Protection for CANDU Nuclear Power Plants* (N293-07) , which is cited in all the licences to operate NPPs. CNSC staff continue to review the updated fire safety assessments. Although the reviews are continuing, the licensees are implementing modifications to address recommendations arising from their updated fire safety assessments. The recommendations identified in the fire safety assessments are not considered to be risk significant. The proposed modifications will increase the safety margin of each facility's fire protection.

14 (i) (d) Probabilistic safety assessments

A PSA is a comprehensive and integrated assessment of the safety of an NPP that considers the probability, progression and consequences of equipment failures or transient conditions to derive numerical estimates that provide a consistent measures of safety:

- A Level 1 PSA identifies and quantifies the sequences of events that may lead to the loss of core structural integrity and massive fuel failures.
- A Level 2 PSA starts from the Level 1 results and analyzes the containment behaviour, evaluates the radionuclides released from the failed fuel and quantifies the releases to the environment.
- A Level 3 PSA starts from the Level 2 results and analyzes the distribution of radionuclides in the environment evaluating the resulting effect on public health.

The main objectives of the PSA are to:

- provide a systematic analysis, to give confidence that the design will comply with the fundamental safety objectives
- demonstrate that a balanced design has been achieved
- provide confidence that a large increase in the severity of consequences caused by a small change of conditions (cliff-edge effects) will be prevented
- assess the probabilities of occurrence for severe core damage states and assessments of the risks of major radioactive releases to the environment
- assess the probabilities of occurrence and the consequences of site-specific external hazards
- identify NPP vulnerabilities and systems for which design improvements or modifications to operational procedures could reduce the probabilities of severe accidents or mitigate their consequences
- assess the adequacy of emergency procedures
- provide insights into the SAM program

PSA requirements are documented in CNSC regulatory standard *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* (S-294). It is cited in existing licences to operate NPPs and would also be applied to the construction phase for new-build projects. One of the key requirements is CNSC acceptance of the methodology and the computer codes used for the PSA. S-294 refers to the IAEA safety series to provide general guidance on PSA methodology. In general, the methodologies developed by the licensees are based on the guidance available in documents issued by internationally recognized organizations such as the IAEA, USNRC and good practices.

S-294 specifically requires a site-specific, Level 2 PSA for all internal events and external events (internal fire, flood and seismic). Consequential events (e.g., external consequential events, such as a tsunami caused by an earthquake) are also considered in the PSAs. The scope of the PSA is limited to full-power and shutdown states of the NPP. S-294 requires the PSA to be updated, in the light of OPEX and significant new safety information, every three years – or sooner, if major changes occur in the facility. The updates are subject to regulatory review.

S-294 is being revised to include amendments regarding lessons learned from Fukushima and to address findings from the CNSC Fukushima Task Force. In the revision of S-294, all sources of radioactivity other than the reactor core will be included. The S-294 revision will also require the consideration of multi-unit effects. The NPP licensees have already started to progress towards compliance with the revised requirements. The PSA update interval in the revision of S-294 is expected to be five years.

The PSA assessments of the probabilities of occurrences for severe core damage states, along with the assessments of the risks of major radioactive releases into the environment, are compared with safety goals. The safety goals for new NPPs, which are established in CNSC regulatory document *Design of New Nuclear Power Plants* (RD-337), are summarized in the table below. These safety goals are consistent with INSAG document *Basic Safety Principles for Nuclear Power Plants* (INSAG-12).

CNSC safety goals

Safety goal	Rationale	Numerical objective
Core damage frequency	Related to accident prevention	Sum of frequencies of all event sequences that can lead to core degradation is less than 10E-5/reactor-year
Small release frequency	Release that would trigger evacuation	Sum of frequencies of all event sequences that can lead to a release of more than 10E+15 Bq of I-131 is less than 10E-5/reactor-year
Large release frequency	Release that would trigger long-term relocation	Sum of frequencies of all event sequences that can lead to a release to the environment of more than 10E+14 Bq of Cesium-137 (corresponds to 1 percent of the Chernobyl accident radioactive release) is less than 10E-6/reactor-year

Although there are no explicit requirements for safety goals at the existing NPPs, the CNSC does expect the licensees of operating NPPs to establish safety goals that are aligned with international practices. Consistent with INSAG-12 and/or IAEA specific safety guide *Development and Application of Level 1 Probabilistic Safety Assessment for Nuclear Power Plants* (SSG-3), the NPP licensees have established and meet, the following safety goals for the existing NPPs:

- core damage frequency of less than 10^{-4}/reactor-year
- large release frequency of less than 10^{-5}/reactor-year

Consistent with international practice, small release frequency is generally not included in the safety goals of existing Canadian NPPs.

Development and use of probabilistic safety assessment

The licensees have either completed, or are in the process of performing, Level 2 PSAs.

The PSAs, their methodologies and their updates are reviewed by CNSC staff to ensure compliance with S-294. During the reporting period, insights from the PSAs were considered by CNSC staff to assess the degree to which the operations of the NPPs continue to meet safety goals. The results of the PSAs and CNSC reviews indicated that the safety goals were met. annex 14(i)(d) reviews the status of the PSAs at the NPPs.

Licensees are at various stages of utilizing the results from their PSAs. Typical applications include PSA use in conjunction with deterministic analytical results to refine programs for reliability and maintenance. For example, PSA results are used to support the identification of the "systems important to safety" for the reliability program (see section 19(iii)). The application of PSA in the assessment of external events is further discussed in subsection 17(iii).

The PSA results have also been used to develop SAM guidelines (SAMGs, discussed in subsection 19(iv)) or for providing insights into the refurbishment process. For the Point Lepreau, Bruce A and Darlington refurbishment projects, PSA results were used to establish the refurbishment scope and the integrated improvement plan. See annex 18(i) for examples of design changes that were implemented during refurbishment to help address issues identified through PSA.

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 revisions of the PSAs for Darlington and Pickering B were used to develop computerized tools for routine risk monitoring, using severe core damage frequency, for both outages and full-power operation. The PSAs have also been used to reduce risk at the NPPs by making changes to operating procedures that improve preparedness for an event. The PSAs will continue to be used to enhance operational risk monitoring programs, and will also provide input to NPP refurbishment decisions. For example, during the reporting period, OPG investigated the implementation of possible cost-effective measures to meet its target core damage frequency for existing NPPs as part of the overall operational plan to the end of life for Pickering A and B.

Response to Fukushima – Probabilistic safety assessment

To help address lessons learned from Fukushima, the following considerations are being included in the draft revision of S-294:

- irradiated fuel bays
- multi-unit station impacts
- low-power operational states
- all potential site-specific external events (including those in combination)

The post-Fukushima safety assessment reviewed PSA results as part of the assessment of provisions for using existing plant capabilities, complementary design features and emergency mitigating equipment in SAM and recovery. Severe accident assessments have been extended to consider further design improvements that have either been implemented or are being planned.

Some of the NPPs that have been subject to ISRs for refurbishment projects were reassessed for external hazards, especially for seismic hazards. PSA-based seismic margin assessments were conducted to assess the safety margin based on earthquakes with a recurrence interval of approximately 10,000 years. A seismic PSAs has also been conducted for Darlington. Other external hazards, including floods and high winds, were also assessed in ISRs.

The CNSC Fukushima Task Force found that the current severe accident models are adequate for single-unit NPPs. The Task Force recommended enhancements of models of beyond-design-basis accidents, including ones developed for multi-unit NPPs. The licensees are enhancing models for beyond-design-basis accidents to align with the requirements of S-294 and are analyzing them systematically – focusing on multi-unit events, irradiated fuel bay events and accidents triggered by extreme external events. Re-evaluation of the site-specific magnitudes of each external event, using modern calculations and state-of-the-art methods, is ongoing. Licensees are re-evaluating if the current site-specific design protection for each external event assessed is sufficient.

Point Lepreau, Darlington and Pickering B have recently updated their PSAs to conform to the requirements of S-294. Seismic, internal flooding and internal fire events are among the events that have been assessed using modern-day methods. Licensees for the other Canadian NPPs, with the exception of Gentilly-2, will complete the upgrades of their PSAs by 2014. Additional information on the status of PSAs at each NPP is provided in annex 14(i)(d).

14 (i) (e) CNSC rating of safety and control areas

CNSC staff assess the licensees' safety performance under each of the 14 CNSC safety and control areas on an annual basis, publishing the assessment in the *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants*. This report integrates information gathered through CNSC staff verification activities of the NPPs and uses a rating system to summarize the performance assessments of each safety and control area for each NPP. An integrated plant rating combining the 14 individual ratings of the safety and control areas is also provided to summarize overall safety performance for each NPP. The CNSC rating system and the 14 safety and control areas are described in more detail in appendix F; the performance ratings of all the safety and control areas for all licensees during the reporting period are listed in table F.3. Overall, CNSC requirements and performance expectations in individual safety and control areas were met or exceeded at all NPPs for all three years of the reporting period – the very few exceptions to this were in 2010. The integrated plant ratings were "satisfactory" or "fully satisfactory" for all NPPs during the entire reporting period.

The ratings of specific safety and control areas are cited in the most relevant articles of this report. One safety and control area that is particularly relevant to this article (article 14) is "safety analysis", which covers deterministic, probabilistic, criticality and robustness analysis, as well as the identification of the safe operating envelope. During the reporting period, all the licensees had satisfactory performance in safety analysis.

14 (i) (f) Reviews by the World Association of Nuclear Operators

The NPP licensees in Canada and AECL are members of WANO, an organization dedicated to helping its members achieve the highest levels of operational safety and performance. WANO conducts periodic evaluations to promote excellence in the operation, maintenance and support of operating NPPs, with a focus on safety and reliability. These evaluations are not required by law or regulation but are requested on a voluntary basis by WANO members.

All WANO reviews are based on performance objectives and criteria developed by WANO with member input and review. The evaluations are performance-oriented, emphasizing both the results achieved and the behaviours and organizational factors important to future performance. The NPP licensees request that WANO to conduct critical peer reviews of performance at their NPPs approximately every two years, with a follow up peer review mid-way through the two-year cycle.

WANO peer-review teams consist of qualified, experienced personnel, including peer evaluators from different utilities, host utility peer evaluators, and an executive industry advisor. They evaluate traditional, functional categories – such as operations, maintenance and engineering – that generally correspond to NPP organization. In addition, teams evaluate cross-functional performance areas: processes and behaviours that cross organizational boundaries and address organizational integration and interfaces, such as safety culture, organizational effectiveness and equipment reliability.

Prior to the peer review, the WANO team leader visits the NPP and selected team members to interview personnel and brief managers on the peer-review process and interactions with the team. Where practical, evolution observations are conducted to observe work during important activities such as outages, start-ups and significant work weeks. Also, the performances of operations and personnel training during simulator exercises are evaluated prior to the peer review at the NPP.

During the two-week review, the peer-review team observes work, writes observation reports, reviews and analyzes information, conducts interviews and discusses results with NPP counterparts. At the end of the review, the peer-review team provides feedback on the NPP's strengths and areas for improvement to enhance safety and reliability. The licensee develops and executes action plans based on the feedback. Approximately 12 months later, a one-week WANO follow-up peer review is conducted to provide feedback on progress made on the action plan.

The following WANO peer reviews were conducted in Canada during the reporting period.

- Bruce A September 2010
- Bruce B March 2012
- Pickering A June 2011
- Pickering B February 2011
- Darlington February 2012
- Gentilly-2 April-March 2011

The feedback, insights and learning from the WANO peer-review process are highly valuable. The process drives major improvements and helps to continually raise the standard of performance and practice across the industry. In support of general improvement, WANO shares good practices identified during reviews with all members. The following two examples illustrate the value of the WANO review process.

In 2009, WANO identified a weakness in Darlington's management and oversight of maintenance strategies for electronic components – specifically, circuit cards. Darlington had experienced some safety system functional failures, the unavailability of a standby generator and lost generation as a result of card failures. In response, Darlington implemented an improved circuit card maintenance and aging management strategy, incorporating best practices that had been recognized by WANO at other NPPs. As a result, Darlington's failure rate has decreased by 50 percent since 2009, with further improvements expected as the full benefits of the initiatives are realized.

Also in 2009, WANO identified that shortfalls in the alpha contamination monitoring program had decreased Pickering's ability to identify elevated levels of alpha contamination and had increased the potential for unknown alpha airborne hazards and worker intakes. In response, Pickering implemented a comprehensive alpha monitoring and control program. A team of plant and corporate health physicists developed and revised 15 procedures to cover all aspects of alpha monitoring and control. For example, a detailed procedure that goes beyond current industry practices was developed to provide guidance for analysis and calculation of internal dose from alpha intakes. The NPP was fully characterized for alpha contamination by the end of 2010. Warning signs were placed at entrances to areas of the plant with elevated alpha activity and alpha contamination frisking was established at each exit. During this time, approximately 4,600 alpha smears were taken. During the 2011 review, WANO concluded that Pickering's efforts were effective in demonstrating that workers and the NPP were protected from alpha contamination and that program details should be shared with the industry at large.

The following WANO peer reviews are planned in Canada during the next reporting period:

- Bruce A and B (corporate) 2013
- Bruce A 2014–2015 (date to be confirmed)
- Bruce B 2014–2015 (date to be confirmed)
- Pickering A and B 2013 and also 2015–16 (date to be confirmed)
- Darlington 2014 and also 2015–16 (date to be confirmed)
- Gentilly-2 No peer reviews scheduled
- Point Lepreau (site) September 2013
- Point Lepreau (corporate) December 2013

During the reporting period, AECL became the first non-NPP organization to become a member of WANO. AECL requested an independent, corporate peer review by WANO to determine how AECL's corporate operations, decision making and governance impact nuclear safety. AECL also sought WANO input on the enhancement of its governance and oversight framework for health, safety, security and the environment. Both initiatives are expected to be completed in 2013.

14 (i) (g) Integrated safety review for life extension

NPP licensees that are proposing to extend their service beyond their nominal design life are required to conduct an ISR. As described in subsection 7.2(ii)(d), the regulatory basis for ISR is founded on specific licence conditions in the licence to operate, as well as CNSC regulatory document *Life Extension of Nuclear Power Plants* (RD-360). RD-360 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 CEAA, all associated regulations and their licence conditions, throughout the life extension projects and subsequent operation.

As part of the ISR, licensees perform a review of the NPP against modern standards and practices. ISR involves a systematic and comprehensive comparison against modern standards and technological developments that assures continued plant safety and viability of the licensing basis. The safety factors to be addressed in an ISR are listed in the IAEA PSR safety guide NS-G-2.10 (and also in IAEA specific safety guide No. SSG-25, *Periodic Safety Review for Nuclear Power Plants,* which replaces it). In addition, the scope of an ISR should address the 14 CNSC safety and control areas that are used in the regulation of NPPs. The CNSC safety and control areas cover all the IAEA safety factors (see table F.2). They also cover waste management, security, safeguards and non-proliferation, and packaging and transport. An ISR should also address all CANDU safety issues and specific CNSC action items applicable to the NPP, with each being resolved to the extent practicable.

A major part of the assessment is to determine the condition of safety-related SSCs. This condition assessment, which includes inspections and analysis, determines 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. Lifecycle management is described in subsection 14(ii)(b).

At the end of the reporting period, CNSC staff issued documents related to staff work instructions to ensure a consistent and transparent approach for the regulatory oversight of NPPs reaching their end of originally intended operating life. A process, a procedure and review instructions were developed for integrated technical assessments of each licensee’s ISR submissions.

For the major life extension projects that were ongoing during the reporting period (Bruce Units 1 and 2 and Point Lepreau), the assessment of safety for the ISR had been conducted during the previous reporting period. The safety improvements that resulting from the subsequent integrated implementation plans are described in annex 18(i).

Hydro-Québec also conducted a full safety assessment as part of its ISR in preparation for the possible life extension of Gentilly-2.

During the reporting period, OPG completed an ISR for Darlington refurbishment and continued operation. At the end of the reporting period, OPG was continuing to develop its global assessment and integrated improvement plan to specify the scope of the refurbishment.

OPG also conducted an extensive ISR in 2010 as part of its assessment of options for the ongoing service of Pickering B to 2020. OPG decided that incremental life extension, rather than shutdown or refurbishment, was the best option, (see subsection D.2 of the “Introduction” for background information). The assessment covered not only various technical areas such as design and operation but also organizational and programmatic issues. This provided valuable input to the continued operations plan and sustainable operations plan. The continued operations plan documents the technical basis actions required to support the incremental life extension of Pickering B. The sustainable operations plan for Pickering B (there is also one for Pickering A) documents the strategic approach to the unique challenges associated with the approach to the end of commercial operation. It describes the arrangements and activities required to demonstrate that safe and reliable operation will be sustained for each of the 14 CNSC safety and control areas. The assessment and the resulting plans for Pickering B are described in detail in annex 14(i)(g) to illustrate the assessment carried out for ISR.

In addition to the ISRs conducted by NPP licensees, AECL conducted an ISR during the reporting period to assess the overall acceptability of continued operation of National Research Universal to 2021 and beyond. AECL followed section 6 of RD-360 and IAEA NS-G-2.10 in the context of a licence renewal of a research reactor.

14 (i) (h) Consideration of periodic safety review for operating NPPs

The regular safety assessments conducted as part of the operating licence renewal process for NPPs (described in subsection 14(i)(b)) are similar in nature and intent to the PSR described in IAEA documentation. As mentioned above, the safety and control areas that provide the framework for the licence renewal safety assessment and ISR cover the IAEA PSR safety factors. The renewal of a licence to operate an NPP typically introduces new standards into the licence on a regular basis.

Challenge C-1 for Canada from the Fifth Review Meeting

"Continue implementation of PSR."

As a potential means of improving the regulatory framework, 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 into the Canadian regulatory process for NPP licensing. The lessons learned through the application of ISRs to NPP refurbishment projects were important considerations. The licensees and CNSC staff concluded that adopting the PSR methodology would result in some benefits with respect to, among other things, regulatory oversight of NPPs. This conclusion was further corroborated by other countries' experiences with applying PSR, both by consultations in national and international fora and via a detailed study conducted by a consultant.

The implementation of PSR in Canada must consider factors such as the frequency of public access to the licensing process, the effectiveness and efficiency of any proposed changes and the additional burden that may be imposed on the regulator and the licensees.

In addition to the discussion of PSR at the Fifth Review Meeting of the CNS, the possible implementation of PSR was the subject of reviews conducted by both the IRRS and the CNSC Fukushima Task Force.

Recommendation R5 from initial IRRS mission in 2009

"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 peer-review team for the follow-up IRRS mission in 2011 noted that the CNSC had made considerable effort in investigating the possibility of implementing PSRs in Canada. The team also noted that ISRs are essentially the same as PSRs, and that ISRs had also been carried out for facilities other than NPPs. Given that the decision to proceed with PSR has not been put to the ultimate, decision-making authority (the Commission), the peer-review team concluded that recommendation R5 remains open.

Suggestion S6 from initial IRRS mission in 2009

"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)."

The peer-review team for the follow-up IRRS mission in 2011 noted that the ISR process, as applied to life extension of NPPs, "contains the same elements as are allocated to PSR in the IAEA safety document NS-G-2.10. It can be stated that … the content requirement is fulfilled but the periodicity of review requirement is not." On the basis that recommendation R5 remained open, the peer-review team closed suggestion S6.

Recognizing that an ISR provides an opportunity to re-evaluate the entire safety case for an NPP, the CNSC Fukushima Task Force considered that PSRs should be done regularly for all NPPs. A 10-year frequency, in line with international practice, was judged reasonable and capable of being integrated into the licensing process. The CNSC Action Plan assigned an action to the CNSC to consider the development of a regulatory framework for the implementation of the PSR process.

CNSC staff have proposed that any ISR conducted for an NPP should be considered the first PSR for that NPP. The CNSC is planning to update RD-360 to focus on periodic performance of ISR, to be conducted in conjunction with licence renewal. The results of such ISR/PSRs, summarized in an integrated implementation plan, would become part of the licensing basis for the NPP.

Recognizing the value of ISR/PSR, OPG has committed to the implementation of a PSR process in support of long-term operation of Darlington, with the first full ISR/PSR submission planned for 2014. Bruce Power has also committed to the implementation of PSR in support of long term operation of Bruce A and B, with the first full PSR submission planned for 2019.

14 (i) (j) Assessment and resolution of CANDU safety issues

Comprehensive provisions for the 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, these provisions 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 improvements to safety that would be realized by these efforts.

In the previous reporting period, the CNSC and industry collaborated on a project to survey generic safety issues related to CANDU NPPs, 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 represents issues that have been satisfactorily addressed in Canada.
- Category 2 represents issues that are a concern in Canada, but appropriate measures are in place to maintain safety margins.
- Category 3 issues are a concern in Canada and measures are in place to maintain safety margins, but the adequacy of these measures needs to be confirmed.

The continued operation of an NPP in the presence of these issues is judged to be permissible – none of the Category 3 issues involves a level of incremental risk that requires immediate corrective action. Issues with confirmed and immediate safety significance are addressed by other means on a priority basis (see subsections 7.2(iii) and (iv).

An RIDM process (see subsection 8.1(d)) was applied in the previous reporting period to the Category 3 issues to identify, estimate and evaluate the risks associated with each issue and to recommend risk control measures. In accordance with defence-in-depth principles, the risk assessment covered all possible combinations of events that could potentially lead to fuel damage; adverse effects 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 risk control measures associated with some of the Category 3 issues is provided in appendix G. The CNSC report describing the Category 3 issues and the required risk control measures is also publicly available.

In order to address the Category 3 CANDU safety issues effectively, these have been logically separated into two groups – those associated with large-break loss-of-coolant accidents (LBLOCAs) and those that are not (referred to as non-LBLOCA issues).

The CNSC maintains regulatory control of the resolution of the safety issues by monitoring the path forward, established through mutual agreement between the CNSC and the NPP licensees. During the reporting period, two of the CANDU safety issues were downgraded from Category 3 to Category 2 for all NPPs:

- channel voiding during an LBLOCA
- hydrogen control measures during accidents

Much of the work to address the other Category 3 CANDU safety issues was also completed during the reporting period. Some of the other issues were downgraded from Category 3 to Category 2 for some (but not all) of the NPPs. The work to address the remaining Category 3 CANDU safety issues will be completed in the next reporting period.

The list of CANDU safety issues surveyed included those that were being addressed by the old set of generic action items (GAIs). GAIs were regulatory tools used to define the scope of certain safety issues, identify technical concerns, specify requirements for their resolution and monitor progress. All GAIs were closed by July 2012, following confirmation that the closure criteria had either been met or were being considered as subsets of the re-categorization criteria under the CANDU safety issues associated with LBLOCA. These remaining issues are expected to be addressed by the end of 2013.

14 (ii) Verification of safety

This subsection describes activities to verify, by analysis, surveillance, testing and/or inspection, that the NPP meets its design and safety requirements and operational limits and conditions. These activities are carried out primarily by the licensee, as discussed in the following subsections. However, the CNSC also conducts various verifications of safety that are described in other articles. For example, the CNSC maintains permanent staff members at each NPP (as described in subsection 8.1(b)) to monitor operations, verify safety in certain circumstances and conduct a wide range of inspections, with assistance from specialists from CNSC headquarters in Ottawa.

CNSC staff also review details in reports submitted by NPP licensees as per CNSC regulatory document S-99. These include event reports and quarterly and annual reports on matters such as operations, performance indicators, periodic inspections, 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 at individual sites. CSNC staff also review the safety analysis reports and safety system reliability studies that are submitted as per S-99.

Furthermore, CNSC staff also review and approve certain operational changes or other changes to items in the licensing basis (see subsection 7.2(ii)(d)). CNSC staff verify that proposed changes are within the licensing basis (e.g., by confirming that they do not significantly erode the margin of safety for the NPP that was agreed upon at the time of licensing).

CNSC licences to operate the existing NPPs contain one or more conditions governing the licensee’s verification of safety through various fitness-for-service programs. The licensees’ programs include testing (see subsection 14(ii)(a) and various aging management programs to address specific critical systems and aging mechanisms (see subsection 14(ii)(b)).

14 (ii) (a) Testing - General

Operating licences for NPPs in Canada cite CNSC document *Reliability Programs for Nuclear Power Plants* (S-98), which includes general requirements for the reliability program for systems important to safety. S-98 addresses the roles of inspection, testing, modelling and monitoring in the identification of systems important to safety, their failure modes and their appropriate reliability targets, as well as confirmation that the targets are met (see subsection 19(iii) for more information). The operating licences also cite other standards that include extensive requirements for testing safety-related components and systems. For example, requirements for testing are found in the following CSA standards that are cited in the licences to operate existing NPPs:

- *Periodic Inspection of CANDU Nuclear Power Plant Components* (N285.4)
- *Periodic Inspection of CANDU Nuclear Power Plant Containment Components* (N285.5)
- *In Service Examination and Testing Requirements for Concrete Containment Structures for CANDU Nuclear Power Plants* (N287.7)

The licensees execute periodic inspection programs for critical components and systems, as described in the next section. Many other CSA standards that are not in NPP operating licences 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 on the order of 99.9 percent. 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. SSCs are subjected to a variety of chemical, mechanical and physical influences during operation. In time, stressors such as corrosion, load variations, flow conditions, temperature and neutron irradiation cause degradation of materials and equipment. This time-dependent degradation is referred to as aging. Aging management is the set of engineering, operational, inspection and maintenance actions that control, within acceptable limits, the effects of physical aging and obsolescence of SSCs occurring over time or with use.

Experience with several significant material degradation mechanisms during the life of currently operating NPPs 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 SSCs are maintained within the safe operating limits allowed by relevant codes and standards. The aging management programs are based on comprehensive methodologies involving 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 review the results of activities covered by the aging management programs.

The main areas under aging management include heat transport system degradation, feeder pipes, fuel channel lifecycle, flow-accelerated corrosion, steam generators, containment and general component replacement. The basic aging management programs for these areas are described in annex 14(ii)(b). The fuel channel lifecycle management project is particularly important in that its results help confirm the safety of ongoing operation of the NPPs as they approach their anticipated end of life, since fuel channels are typically the major life-limiting component in the CANDU design.

Requirements for periodic inspection of nuclear pressure boundary components, containment components and containment structures are established in the operating licences for all NPPs by the citation of CSA standards N285.4, N285.5 and N287.7, which establish minimum inspection requirements and acceptance criteria for the in-scope components and structures.

The CNSC issued the regulatory document *Aging Management of Nuclear Power Plants* (RD-334) during the reporting period to provide regulatory requirements for aging management. The requirements in RD-334 are consistent with the guidance in the IAEA safety guide *Ageing Management for Nuclear Power Plants* (NS-G-2.12). RD-334 emphasizes the need for early and proactive consideration of aging management for all stages of an NPP’s lifecycle: design, fabrication, construction, commissioning, operation, life extension, and decommissioning. As well, RD-334 provides requirements for the establishment, implementation and improvement of integrated aging management programs, through the application of a systematic and integrated approach. The approach includes organizational arrangements, data management, SSC selection, aging evaluation and condition assessment processes, documentation and interfaces with other supporting program areas such as the review and improvement of the program.

During the reporting period, the NPP licensees began to adapt their aging management programs, as necessary, to meet the requirements in RD-334. The CNSC began referencing RD-334 in the NPP operating licences as they were renewed.

The CNSC has also established a licence condition requiring that licensees develop inspection programs to monitor the conditions of safety-significant, balance-of-plant pressure boundary components and structures (containment structures are addressed by separate licence requirements). Industry and the CNSC are working together on the development of a CSA standard that will provide minimum periodic inspection requirements for balance-of-plant pressure boundary components; it is anticipated that this standard will be published in 2014.

Article 15 – Radiation Protection

> Each Contracting Party shall take the appropriate steps to ensure that in all operational states the radiation exposure to the workers and the public caused by a nuclear installation shall be kept as low as reasonably achievable and that no individual shall be exposed to radiation doses which exceed prescribed national dose limits.

Canada sponsors significant R&D in the field of nuclear safety, as described in appendix E. A significant portion of the activity addresses the areas of radiation protection, radiation monitoring, environmental protection, environmental management and other related topics.

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 (i.e., the public)

The dose limits in the *Radiation Protection Regulations*, which came into force in 2000, were primarily based on International Commission on Radiation Protection (ICRP) Publication 60, published in 1991.

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 (if appropriate) take action to restore the effectiveness of the radiation protection program. The CNSC document *Reporting Requirements for Operating Nuclear Power Plants* (S-99), which is cited in the licences to operate NPPs, requires licensees to file a report to the CNSC within 45 days of awareness 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, identify any missing information, and further describe how and when the remaining information will be provided to the CNSC.

Additional information on the *Radiation Protection Regulations,* dosimetry requirements, and guidance related to the ALARA principle and the setting of action levels is provided in annex 15(a). The possible amendment of the *Radiation Protection Regulations* to address lessons learned from Fukushima related to doses during the phases of an emergency is discussed in subsection 16.1(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 consistent 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) 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 all Canadian NPPs.

To fulfill the relevant requirements for radiation and environmental protection, 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 ensure that the exposures to workers are ALARA, the licensees are required to implement processes 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 review documentation and operational reports submitted by licensees and evaluate the implementation of licensees' radiation protection and environmental protection programs through desktop reviews and onsite inspections.

CNSC staff also:

- monitor and evaluate the radiological and environmental impacts of licensed activities
- review documentation and applications submitted by licensees
- conduct onsite evaluations of licensed dosimetry service providers

For events (reported through S-99) related to potential and actual exposure to radiation and hazardous substances, CNSC staff review the reporting and analysis processes of licensees, to verify their compliance with regulatory requirements and their 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 (i.e., hot spots) reduction.

Radiological exposure permits set out job-specific exposure restrictions for all planned and emergent radiological work. Job exposure restrictions are determined through the use of OPEX and pre-job assessments of the work environment for radiological hazards. The ALARA planning divisions of the NPPs assess assigned job-specific exposure restrictions 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 identify and communicate **radiation protection-related challenges** during pre-job briefings. This strategy reduces the probability of unplanned exposures that exceed a predefined investigation level, and it also facilitates post-work ALARA reviews of high-hazard or high-dose jobs.

Various measures are in place to reduce doses to workers from exposure to tritium and to train workers on potential tritium hazards. The measures include more frequent replacement of desiccant in dryer units and improvement of the material condition of dryer systems. Some licensees have dehumidifiers on the air inlets of reactor buildings and/or alarming area tritium monitors. Some licensees also de-tritiate their heavy-water inventory. To further limit tritium exposure, some licensees reinforce the need to plug in plastic suits at every opportunity in order to refill them with fresh air (thereby limiting unplugged periods to less than 60 seconds).

Hot spots, which can increase ambient radiation fields and contribute to radiation doses, are identified and removed or shielded. In addition, licensees are working to reduce the recurrence of hot spots through initiatives involving either reduction of the filter pore size or an increase in the flow rate of the heat transport purification system.

Each year, licensees establish challenging radiation dose performance targets, which are analogous to 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 workers were below regulatory limits during the reporting period (see annex 15(b), which charts and discusses doses to workers at Canadian NPPs). During the reporting period, the total collective dose at Canadian NPPs varied due to a number of factors such as:

- the dose rates associated with the type of work being performed
- the number of outages each year
- the scope and duration of outage work
- the number of people involved in outage work

The fifth Canadian report described a significant event at Bruce Unit 1 in 2009 that involved elevated levels of airborne alpha contamination during refurbishment work and potential exposures of a large number of workers. At the time, the 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. The licensee engaged an independent third party to help resolve any issues that were identified and to review its handling of the situation. The follow-up to that event is summarized in annex 15(b).

Licensee performance under the “radiation protection” safety and control area is reported annually for all operating NPPs in the *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants*. This safety and control area covers aspects of radiation protection for workers; radiation protection for the public is covered by a separate safety and control area (“environmental protection”, described below). During the reporting period, all licensees had satisfactory performance for the radiation protection safety and control area. See appendix F for a full definition of this safety and control area (table F.1) and for 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 emissions and liquid effluents from NPPs can result in radiation doses to members of the public through environmental exposure pathways. The doses received by the public from routine releases from NPPs are too low to measure directly. Therefore, to ensure that the public dose limit is not exceeded, the CNSC restricts the amount of radioactive material that licensees may release. These effluent limits are derived from the public dose limit of 1 mSv, and are called derived release limits (DRLs). A DRL for a given radionuclide/radionuclide group is an effluent release limit for a route of release from an NPP. If the total of the measured releases for each effluent, expressed as percentages of their respective DRLs, exceeds 100 percent, members of the public with the greatest exposure may exceed the public dose limit over the calendar year. The phrase “members of the public with the greatest exposure” refers to individuals who receive the highest doses from a particular source due to factors such as proximity to the release, dietary and behavioural habits, age and metabolism, and variations in the environment.

The calculation of DRLs is based on methodology in the CSA standard *Guidelines for Calculating Derived Release Limits for Radioactive Material* (N288.1). The CNSC began adding N288.1 to the existing licences to operate NPPs during the reporting period. DRLs are also based on other developments in radiation protection (e.g., ICRP dose conversion factors). DRLs are unique to each facility, vary in values, and depend on several factors (assumptions, representative person characteristics, site-specific data, etc). The calculation of DRLs can vary from simple to exceedingly complex. As a result, DRLs should be reviewed and, if necessary, updated approximately every five years.

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 effluent and gaseous emission 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 emissions and liquid effluents from Canadian NPPs from 2010 to 2012 are tabulated in annex 15(c). During the reporting period, the majority of releases from all NPPs were kept at less than 1 percent of the DRLs. From 2010 to 2012, there were no reported cases of environmental action levels being exceeded.

In addition to tracking radiological emissions from the NPP, licensees have radiological environmental monitoring programs to monitor radioactivity around the facilities in the air, water and food chain products. These environmental monitoring programs have the following four objectives:

- to confirm that emissions of radioactive materials are within the DRLs for specific nuclides or nuclide groups
- to verify that the assumptions made in deriving DRLs remain valid
- to assess doses to critical members of the public resulting from releases
- to provide data used in the development and evaluation of models that adequately describe the behaviour of radionuclides in 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. (See appendix C of Canada's report to the Second Extraordinary Meeting of the CNS for additional details.) The Ontario Ministry of Labour's Radiation Protection Service also monitors environmental radiation, within the province of Ontario.

Release of hazardous substances

In addition to regulating the control of radioactive 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

Licensee performance under the "environmental protection" safety and control area is assessed annually for all NPPs in the *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants*. This safety and control area covers radiological exposure of the public and the environment to radioactive and hazardous substances. During the reporting period, all licensees demonstrated satisfactory performance under this safety and control area. See appendix F for a full definition of this safety and control area (table F.1) and for 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 on-site and off-site emergency plans that are routinely tested for nuclear installations and cover the activities to be carried out in the event of an emergency. For any new nuclear installation, such plans shall be prepared and tested before it commences operation above a low power level agreed by the regulatory body.
2. Each Contracting Party shall take the appropriate steps to ensure that, insofar as they are likely to be affected by a radiological emergency, its own population and the competent authorities of the States in the vicinity of the nuclear installation are provided with appropriate information for emergency planning and response.
3. Contracting parties which do not have a nuclear installation on their territory, insofar as they are likely to be affected in the event of a radiological emergency at a nuclear installation in the vicinity, shall take the appropriate steps for the preparation and testing of emergency plans for their territory that cover the activities to be carried out in the event of such an emergency.

16.1 Emergency plans and programs

16.1 (a) General responsibilities of the licensees, regulatory body and other authorities

In Canada, licensees of nuclear facilities are responsible for onsite emergency planning, preparedness and response. Onsite nuclear emergencies are those that occur within the physical boundaries of a Canadian NPP.

Offsite nuclear emergencies are those emergencies having an effect outside the boundaries of a Canadian NPP. In the event of an NPP accident with potential offsite consequences, the offsite response would follow a tiered process involving the following parties:

- the licensee
- municipal government
- provincial/territorial governments
- federal government

The provincial governments are responsible for:

- overseeing public health and safety and protection of property and the environment
- enacting legislation to fulfill the province's lead responsibility for public safety
- preparing emergency plans and procedures and providing direction to municipalities that they designate to do the same
- managing the offsite response by supporting and coordinating the efforts of organizations with responsibility in a nuclear emergency
- coordinating support from the NPP licensee and the Government of Canada during preparedness activities and response in a nuclear emergency

Federal government support and response for potential offsite impacts are required for addressing areas of federal responsibility, including an incident's effects that extend beyond provincial and/or national borders. Likewise, the coordination of federal assistance when requested by an affected province is also required. Some provinces have pre-agreements with the federal government for the provision of specific types of technical support. Federal responsibility also encompasses a wide range of contingency and response measures to prevent, correct or eliminate accidents, spills, abnormal situations and emergencies, and to support provinces and territories in their responses to a nuclear emergency. The Government of Canada is also responsible for:

- liaison with the international community
- liaison with diplomatic missions in Canada
- the assistance of Canadians abroad
- coordination of the national response to a nuclear emergency occurring in a foreign country

Public Safety Canada was created in 2003 to ensure coordination across all federal departments and agencies responsible for national security and the safety of Canadians. It is responsible for coordinating the overall federal government response to emergencies in support of provinces, including nuclear emergencies. In 2007, the Government of Canada replaced the former *Emergency Preparedness Act* with the modernized *Emergency Management Act* (EMA). The EMA provides the legislative basis and broad policy direction for federal government ministers and their respective departments/agencies, broadening the scope of emergency preparedness at the federal level to include the four pillars of emergency management: mitigation, preparedness, response and recovery.

Public Safety Canada is the lead authority for the Federal Emergency Response Plan (FERP). Health Canada is the lead authority for the Federal Nuclear Emergency Plan (FNEP) and also has responsibilities related to radiation protection. Health Canada administers a federal inter-departmental and a federal–provincial nuclear emergency management committee.

Other federal organizations with responsibilities in nuclear emergency preparedness and response include the CNSC, Transport Canada, Environment Canada and NRCan. NRCan is responsible for providing emergency radiation mapping and surveying services, providing policy advice and coordinating federal actions in relation to nuclear liability. Transport Canada is responsible for the Canadian Transport Emergency Centre. Internationally, Health Canada and the CNSC serve as national competent authorities to the IAEA. Environment Canada is a Regional Specialized Meteorological Centre under the World Meteorological Organization, and provides atmospheric modelling services to the IAEA as part of its emergency response functions. The Public Health Agency of Canada is the national authority for reporting to the World Health Organization under the International Health Regulations.

Response to Fukushima – Emergency preparedness in general

In response to Fukushima, several federal organizations, including the CNSC, Health Canada, Public Safety Canada, and the Department of Foreign Affairs, Trade and Development, conducted reviews to identify lessons learned and next steps. The CNSC Fukushima Task Force developed its *Nuclear Power Plant Safety Review Criteria* to help guide the assessment of not only the licensees' emergency preparedness measures but also the measures of other key authorities in emergency preparedness, such as the provinces and various federal departments. Public Safety Canada also developed a whole-of-government *After Incident Report* and an accompanying *Capability Improvement Process Matrix* to track all the observations identified during the incident and to propose recommendations and corrective actions, as well as to identify best practices.

The various lessons-learned reviews include consultation among relevant organizations to help resolve certain issues related to emergency preparedness in Canada. This subsection provides a general description of the response to Fukushima and findings that cut across multiple organizations or jurisdictions. More specific findings relevant to individual organizations or jurisdictions are described in other subsections throughout this article.

The CNSC Fukushima Task Force reviewed the plans and capabilities of lead provincial and federal agencies to identify any outstanding issues related to coordinated nuclear emergency management. Overall, coordination among the various organizations is good – all players work together to ensure that the safety of the public and environment will be protected during an extreme event. Also, the offsite support components of the licensees' emergency response plans are adequately implemented and tested regularly by drills and exercises. In all, there are no significant gaps in emergency preparedness, i.e., no issues exist that require immediate action at the NPP, municipal, provincial or federal level.

As emergency preparedness lessons were learned from Fukushima, the NPP licensees and various emergency response organizations participated in several workshops to identify and address areas for improvement. For example, COG organized three workshops during the reporting period that involved NPP licensees and governmental and non-governmental institutions that would play roles in a response to a nuclear emergency. The third workshop included a tabletop exercise highlighting the events that would occur outside the boundaries of the NPP during a nuclear emergency.

Among the lessons learned and conclusions of the various reviews were issues that should be addressed across multiple levels of emergency preparedness. One such issue was the discrepancy between the oversight of offsite emergency preparedness versus onsite emergency preparedness.

The CNSC Fukushima Task Force found that communications protocols among the licensees and the offsite response organizations, including provinces, municipalities and the CNSC, are well documented in both the licensees' emergency response plans and procedures and those of the offsite organizations. During the planning and preparedness phases of emergency management, all licensees work closely with their respective offsite emergency response stakeholders to maintain good working relationships. In addition, the provinces, the Government of Canada and the licensees work co-operatively through coordinated information functions to provide the public and the media with information about the status of the crisis and other relevant information. Effective coordination of communications among licensees and offsite authorities related to decision making and public/media affairs has been observed during coordinated emergency exercises.

The NPP licensees are required by the *Class I Nuclear Facilities Regulations* to submit their onsite emergency plans to the CNSC as part of the licence application and renewal process. The NPP licensees' onsite emergency plans, programs and performance are included in the CNSC regulatory oversight process (see subsection 16.1(b) for details). However, the *Class I Nuclear Facilities Regulations* do not currently require submission of offsite emergency plans with an NPP operating licence application (although the CNSC has always considered the preparedness of the offsite authorities when reviewing a licence application). The CNSC Action Plan assigned an action to the CNSC to initiate a project to amend the *Class I Nuclear Facilities Regulations* to require submission of applicable provincial and municipal offsite emergency plans, along with evidence to support how the licensees are meeting the requirements of those plans, as part of the licence application. The CNSC plans to post the proposed amendments in the *Canada Gazette*, Part I for formal consultation in the fall of 2013.

The CNSC Fukushima Task Force, recognizing that emergency preparedness is the joint responsibility of the licensees and host municipalities and provinces, noted the need for a formal, national oversight process for offsite nuclear emergency plans, programs and performance. Although an emergency management planning guide provides generic guidance to develop all hazards emergency management plans, the Task Force noted that there is no established national guidance or standard for offsite nuclear emergency planning.

The Fukushima review during the IRRS follow-up mission to Canada had a similar finding.

Recommendation RF7 from follow-up IRRS mission in 2011

"The Government of Canada should assure that the review and assessment of off-site emergency plans for nuclear power plants include all relevant authorities and are comprehensive and that the relevant organizations which implement those plans are capable of performing the assigned duties."

The CNSC Action Plan assigned an action to the CNSC to initiate and facilitate discussions with provincial and federal nuclear emergency planning authorities to ensure understanding of these findings and to pursue recommended solutions.

Health Canada has taken the lead on addressing this finding and is reviewing the national level oversight of offsite nuclear emergency plans, programs and performance through the use of its federal and provincial coordinating committees for nuclear emergency management. In parallel with the renewal and approval of the FNEP in 2012, Health Canada's federal and federal – provincial nuclear emergency management committees were formally placed within the all-hazards governance structures established by Public Safety Canada in order to strengthen their reporting and oversight. Review and assessment is also ongoing at the provincial level. Provincial authorities, including the municipalities, are working closely with the NPP licensees and other partners to review emergency preparedness plans, processes, arrangements, training and future exercises. They are also looking at the effectiveness of some of their processes for protecting the public.

The CNSC Fukushima Task Force also found that the *Radiation Protection Regulations* should be reviewed for potential revisions, based on lessons learned from Fukushima. Additional regulatory requirements may be needed for the radiation protection of workers to control doses according to the severity and phases of an emergency, and that applicable guidance should be given to minimize doses. The CNSC plans, in the summer of 2013, to post a discussion paper for public comment on the proposed amendments, which include those designed to address the CNSC Task Force recommendations. The amendments will introduce additional clarity on emergency dose limits for workers during the phases of an emergency and establish return-to-work criteria.

The Task Force noted that, although various organizations and jurisdictions have routinely exercised their plans and capabilities in a range of exercises, the effectiveness of all arrangements has not been tested in a full-scale national exercise since 1999. The Task Force recommended actions to help address identified shortcomings in conjunction with the key stakeholders.

The Fukushima review during the IRRS follow-up mission to Canada had a similar finding.

Recommendation RF8 from follow-up IRRS mission in 2011

"The Government of Canada should assure that full-scale exercises of off-site emergency preparedness plans be held on a periodic basis, including participation of the licensee and the municipal, provincial and federal organizations."

The CNSC Action Plan assigned an action to the CNSC to initiate and facilitate discussions with provincial and federal nuclear emergency planning authorities to ensure understanding of these findings and to pursue recommended solutions.

The federal deputy ministers instructed that the revised FNEP be tested in a national-level exercise, currently planned for May 2014 and intended to be the first in an ongoing series of periodic exercises involving all jurisdictions. See subsection 16.1(f) for details.

Based on the above IRRS findings that apply to multiple authorities responsible for nuclear emergency preparedness, the Fukushima review during the IRRS follow-up mission to Canada also found that Canada would benefit from an international peer review of emergency preparedness.

Suggestion SF9 from follow-up IRRS mission in 2011

"The Government of Canada should consider inviting an international peer review mission for emergency preparedness and response."

The CNSC will initiate and facilitate discussions with federal and provincial nuclear emergency planning authorities to address this suggestion. Canada is considering an international peer review of emergency preparedness that could address aspects of offsite emergency plans at various levels.

16.1 (b) Onsite emergency plans

The NPP licensees are responsible for onsite preparedness and response. Paragraph 6(k) of the *Class I Nuclear Facilities Regulations* specifies the information related to emergency preparedness that must accompany an application for a licence. Specifically, the application must describe the proposed measures to:

- assist offsite authorities in planning and preparing to limit the effects of an accidental release
- notify offsite authorities of an accidental release or the imminence of an accidental release
- report information to offsite authorities during and after an accidental release
- assist offsite authorities in dealing with the effects of an accidental release
- test the implementation of the measures to prevent or mitigate the effects of an accidental release

The application should describe the proposed facility, activities, substances and circumstances to which its emergency plans apply. The emergency plans should also be commensurate with the complexity of the associated undertakings, along with the probability and potential severity of the emergency scenarios associated with the operation of the facility.

Each licensee's emergency plan is specific to its particular site and organization; however, all typically cover:

- documentation of the emergency plan
- basis for emergency planning
- personnel selection and qualification
- emergency preparedness and response organizations
- staffing levels
- emergency training, drills and exercises
- emergency facilities and equipment
- emergency procedures
- assessment of emergency response capability
- assessment of accidents
- activation and termination of emergency responses
- protection of facility personnel and equipment
- interface arrangements with offsite organizations
- arrangements with other agencies or parties for assistance
- recovery program
- public information program
- public education program

The NPP licensees' public information programs are described in subsection 16.2(a).

The licensees routinely conduct self-audited emergency drills and, less frequently, full-scale exercises directly involving offsite provincial and, where applicable, municipal emergency response organizations. See subsection 16.1(f) for more details.

After the plans have been reviewed and accepted by the CNSC, they become binding upon the licensee as part of the licensing basis. Descriptions of the onsite emergency plans for each NPP are provided in annex 16.1(b).

A condition in each licence to operate an NPP requires the licensee to implement an emergency preparedness program to ensure it is capable of executing its plan. Emergency preparedness plans and programs are updated and fine-tuned over the life of the NPP as new requirements are identified, or to address changing conditions, OPEX, and identified deficiencies. The CNSC assesses licensees' emergency preparedness programs and inspects their emergency drills and exercises. The CNSC would continue to have regulatory oversight of the licensees during a nuclear emergency. Notwithstanding the fact that the programs have matured and are well maintained, CNSC staff have observed that NPP licensees in Canada proactively seek ways to continuously improve their emergency preparedness programs.

Licensee performance under the "emergency management and fire protection" safety and control area is assessed annually for all NPPs in the *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants*. During the reporting period, all licensees had satisfactory performance in this safety and control area. See appendix F for a full definition of this safety and control area (table F.1) and for the performance ratings of the licensees during the reporting period (table F.2).

Response to Fukushima – Onsite emergency plans

The CNSC Fukushima Task Force observed that, although each licensee has its own means and methods of meeting the emergency preparedness and response expectations (discussed below), there is no regulatory requirement or standard to ensure consistency among the licensees. The suite of emergency preparedness regulatory documents currently comprise the following:

- *Emergency Planning at Class I Nuclear Facilities and Uranium Mines and Mills* (G-225)
- *Testing the Implementation of Emergency Measures* (RD-353)

The CNSC Action Plan assigned an action to the CNSC to develop a dedicated regulatory document on emergency management that incorporates the information in G-225 and RD-353 and to review and update the document. The CNSC plans to consult publicly on this draft document in the summer of 2013. It is worth noting that the CSA Group has also identified the need for a new standard on nuclear emergency management that would complement the regulatory requirements (see subsection 7.2(i)(b) for additional details on the assessment of CSA standards).

The CNSC Fukushima Task Force found that the licensees' emergency plans exceeded the expectations for design-basis accidents (no offsite dose consequences). The licensees' emergency response organizations were and remain capable of responding to single-unit, beyond-design-basis accidents. Evaluation and revision of emergency plans in regard to multi-unit accidents and severe external events (e.g., conducting exercises based on severe event and/or multi-unit accident conditions), including an assessment of the staff requirements, however, had not been performed. As a result, it had not been conclusively demonstrated that the licensees' emergency response organizations would be capable of responding effectively in a severe event and/or multi-unit accident. The CNSC Action Plan assigned an action to the licensees to evaluate and revise their emergency plans with regard to multi-unit accidents and severe external events. This activity was to include an assessment of their staff requirements to ensure their emergency response organizations are capable of responding effectively to multi-unit accidents or to severe natural disaster events. All NPPs submitted their assessments to the CNSC. With the exception of Gentilly-2, the evaluation of the adequacy of existing emergency plans and programs has been accepted by the CNSC and is closed for affected NPPs.

The CNSC Action Plan also assigned an action to the licensees to review their drill and exercise programs to ensure they are sufficiently challenging to test the performance of the emergency response organizations under severe events and/or multi-unit-accident conditions. With the exception of Gentilly-2, plans and schedules for the development of improved exercise programs have been accepted by the CNSC for affected NPPs. Large-scale exercises were conducted in 2012 and 2013 by NBPN and Bruce Power, respectively, and one is scheduled for OPG in May 2014. Further details on emergency exercises are discussed in subsection 16.1(f).

The licensees are effectively integrating SAMGs into their emergency plans, enhancing their training and clarifying roles in their emergency response organizations (discussed in article 19).

Emergency facilities and equipment designated as essential for emergency response must always be available, accessible and ready to operate. The CNSC Fukushima Task Force noted that not all licensees' emergency facilities and equipment had backup power available in the event of a loss of external power. In some cases, backup power sources for primary and alternate emergency facilities and emergency response equipment had not been systematically identified. The applicable emergency plans and procedures did not, in all cases, adequately document the requirements and limitations related to the backup power supply. The CNSC Action Plan assigned an action to the licensees to review primary and alternate emergency facilities, along with all emergency response equipment requiring electrical power to operate (e.g., electronic dosimeters, two-way radios), to ensure that appropriate backup power sources exist. The requirements and limitations are to be documented in the applicable emergency plans and procedures.

During the reporting period, those licensees that did have backup power for emergency facilities and equipment investigated their abilities to maintain backup power for extended outages and corrected any identified deficiencies. Those licensees that did not have backup power for their emergency facilities and/or equipment identified the weaknesses and assessed their needs and options. An evaluation of the adequacy of backup power for emergency facilities and equipment was completed by all affected NPPs and accepted by the CNSC during the reporting period.

The availability of backup power for the CANDU reactor itself is discussed in article 18.

The external resources currently available to the licensees onsite are adequate for coping with design-basis accidents and many beyond-design-basis accidents. For an external event affecting the whole site, or in the event of a severe accident that might progress over several days, it would be necessary to bring in offsite resources.

The review of lessons from Fukushima considered formal plans for inter-utility co-operation in matters such as availability of skilled personnel, provision of technical support and the sharing of equipment. It was noted that the licensees' emergency response organizations did not have access to a regional warehouse that could make offsite equipment and resources available should they be needed in case of a severe accident. The CNSC Action Plan assigned an action to licensees to procure emergency equipment and other resources that could be stored offsite and brought onsite to mitigate a severe accident. The licensees are co-operating to establish formal agreements and designating or building a regional warehouse for storing necessary equipment and resources in case of emergency. In the short term, licensees are acquiring emergency equipment such as portable pumps and generators to be stored onsite and offsite, to ensure reactors can be brought to a safe shutdown state in any credible accident scenario. All affected NPPs have provided plans and schedules for the procurement of emergency equipment and offsite storage. The CNSC is satisfied with the acquisition equipment thus far and with the preparations for offsite storage by the NPPs.

All licensees have agreements in place with their respective stakeholders for support and supplies during emergencies. The Task Force noted, however, that the licensees' arrangements for support and supplies were not consistently formalized or documented, in most cases, in their emergency plans and procedures. The CNSC Action Plan assigned an action to licensees to formalize all arrangements and agreements for external support and to document these in the applicable emergency plans and procedures.

The licensees are confirming that their arrangements will work in an actual accident. The licensees worked together through COG to develop and sign an industry-wide Mutual Aid

Agreement and document it in their emergency plans and procedures. Formal arrangements were completed in 2012.

16.1 (c) Emergency preparedness expectations for new-build projects

The CNSC is establishing requirements and expectations for emergency preparedness for new-build projects. The CNSC 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 a proposed site against safety goals is being evaluated:

- 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 (e.g., schools, prisons and hospitals)
- the ability to maintain population and land-use activities in the protective zone at levels not impeding 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.

Expectations for emergency preparedness will be conveyed, at a high level, to potential applicants in an application guide for a licence to prepare a 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.

Prior to construction, the proponent is expected to confirm with the surrounding municipalities and the affected provinces, territories and neighbouring countries that the implementation of 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 has issued the document *Licence Application Guide: Licence to Construct a Nuclear Power Plant* (RD/GD-369), which elaborates on these expectations.

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 accident management and emergency procedures.

16.1 (d) Offsite (provincial and territorial) emergency plans

The provincial/territorial governments are responsible for overseeing the health, safety and property of their inhabitants and the protection of the environment within their jurisdictions. Accordingly, they assume lead responsibility for the arrangements necessary to respond to the offsite effects of a nuclear emergency, by enacting legislation and providing direction to the municipalities where the NPPs are located. Typically, their administrative structures include an emergency measures organization, or the equivalent, to cope with a wide range of potential or actual emergencies in accordance with defined plans and procedures. The provinces maintain emergency operations centres to coordinate protective actions for the public and to provide the media with information. In addition, the provincial governments coordinate support from the licensees, from the Government of Canada and from departments and agents of all levels of government during the preparedness activities, as well as during the response.

The provinces coordinate the efforts to deal with any significant offsite nuclear impacts. An important aspect are the arrangements for urgent, protective action, which include:

- limiting access to the affected zone(s)
- providing temporary shelter to the affected population
- evacuating buildings or premises in areas near the NPP
- distribution of potassium-iodide to the affected population to block thyroid uptake of radiation
- implementing ingestion control measures such as quarantining farm animals, banning the sale of affected foodstuff and restricting the use of affected drinking water
- establishing emergency worker centres and reception centres

The offsite nuclear emergency plans of the provinces that host NPPs are described in annex 16.1(d). Additional details for each provincial plan, including a description of planning zones, event assessment, public alerting and protective measures, are provided in appendix B of Canada’s report to the Second Extraordinary Meeting of the CNS.

Response to Fukushima – General adequacy of offsite emergency plans

Provincial agencies participated in the overall, national reviews of the Fukushima lessons learned.

The CNSC Fukushima Task Force concluded that there are no emergency response issues requiring immediate action at the provincial level. Although some opportunities for improvement were identified, each province, overall, has developed well-documented emergency plans. These plans and their elements are well integrated in the licensees’ onsite emergency plans. See Canada’s report to the Second Extraordinary Meeting of the CNS for more detailed discussion of provincial emergency plans in light of Fukushima.

The provinces, in conjunction with the CNSC, Health Canada and Public Safety Canada are pursuing the resolution of the following issues:

- Provincial plans primarily address preparedness and response, but no guidelines and plans exist for the recovery phase.
- Full-scale emergency exercises should have a higher priority at the provincial level.

Response to Fukushima – Licensee support for offsite emergency preparedness

The CNSC Fukushima Task Force confirmed that offsite support components of the licensees' emergency response plans are comprehensive, adequately documented and implemented, and met the requirements of their respective provincial offsite emergency response plans. There are no offsite emergency response issues that require immediate action at the licensee level. Nevertheless, the NPP licensees are working on improvements in areas where they support offsite emergency preparedness: source term estimation, plume modelling, radiation monitoring and dose modelling.

Post-accident source term estimation is a method that can be used to quantify a potential release of radioactive material before it occurs. Bruce, Pickering A and B, and Darlington use software and in-plant gamma survey measurements to perform post-accident source term estimations. However, these provisions are designed for an accident in only one unit, so Bruce Power and OPG are expanding their applicability to multi-unit accidents. Gentilly-2 and Point Lepreau do not perform source term estimation in support of offsite emergency response. Recognizing that providing source term estimation to offsite authorities in emergency situations is a best practice, the CNSC Fukushima Task Force recommended that Gentilly-2 and Point Lepreau develop source term estimation capability. The recommendation is being addressed through the response to an action on dose modelling, which is discussed below.

All licensees have a plume modelling capability that can be used to guide field survey teams and to inform offsite authorities about the potential spread of radiation releases in the event of an accident. This can be supported by federal plume modelling capabilities, if required. The multi-unit NPPs (Bruce, Pickering A and B, and Darlington) have software capable of providing plume modelling for multi-unit events. OPG and Bruce Power are involved (through EPRI) with international efforts to assess improvements in plume modelling based on observations during Fukushima.

All licensees perform field radiation monitoring by dispatching dedicated monitoring teams to designated locations, both onsite and offsite, to collect measurements using gamma dose rate metres and air samplers as determined by the plume modelling results. Some licensees have arrangements with Health Canada for the operation and sharing of data from fixed point gamma monitors around their facilities. Some licensees have an automated system that provides real-time field monitoring data in addition to the results collected by its field monitoring teams. Some licensees have implemented automated, solar-powered near-boundary monitoring. In all cases, field radiation monitoring results are relayed to the provincial authorities, as well as to the CNSC, to be used to assess and determine which protective actions should be recommended for the public.

The CNSC Fukushima Task Force concluded that all licensees had satisfactory arrangements in place to perform field radiation monitoring. However, for most licensees, the method depended on the presence of staff in the field to collect samples and take readings. Recognizing that the use of automated real-time field monitoring at an NPP boundary is a best practice, the CNSC Action Plan assigned an action to licensees to install automated real-time NPP boundary radiation monitoring systems with appropriate backup power and communications systems. The installation of real-time boundary monitoring for most NPPs is planned or completed.

Bruce, Pickering A and B and Darlington perform dose modelling based on source term estimates, the monitoring of venting radiation and field surveys. Hydro-Québec performs dose modelling based on the monitoring of venting radiation, fixed radiation surveillance station data, and field surveys. Although the CNSC Action Plan assigned an action on Gentilly-2 to ensure that source term estimates are included in dose modelling, the action was suspended following the announcement of its closure. The CNSC Action Plan also assigned an action on Point Lepreau to develop source term estimation in support of comprehensive dose modelling. The CNSC subsequently accepted NBPN's submissions of revised emergency procedures for Point Lepreau that include plans for offsite source term estimation in coordination with Health Canada. The CNSC also accepted the arrangement in New Brunswick whereby the offsite emergency response authority relies on dose modelling by Health Canada as part of its decision support.

16.1 (e) Federal emergency plans

The Government of Canada's emergency planning, preparedness and response are based on an "all-hazards" approach. The *Emergency Management Act* sets out general responsibilities for Public Safety Canada and all other federal ministers. Public Safety Canada has prepared the all-hazards FERP to address governance and coordination issues for federal entities and to support the provinces and territories. The federal Minister of Public Safety is responsible for coordinating the Government of Canada's response to an emergency. The FERP is designed to harmonize federal emergency response efforts with those of the provinces and territorial governments, non-government organizations and the private sector, through processes and mechanisms that facilitate an integrated response.

Because of the inherent technical nature and complexity of a nuclear emergency, hazard-specific planning, preparedness and response arrangements are required. The Radiation Protection Bureau of Health Canada administers the comprehensive FNEP, which is integrated with and forms an annex to the FERP to coordinate the federal government technical response and support to Canadian provinces and/or territories for managing the radiological consequences of any domestic, trans-boundary or international nuclear emergency. The FNEP complements the relevant nuclear emergency plans of other jurisdictions inside and outside Canada.

The FERP and FNEP were updated in 2011 and 2012, respectively; the updates addressed the lessons learned from Fukushima.

The FNEP describes the roles and responsibilities of federal departments and agencies and the measures they should follow to manage and coordinate the federal response to a nuclear emergency based on the scenarios identified in the plan, focusing on the provision of coordinated scientific support to manage radiological consequences. There are 18 federal departments and agencies involved with respect to FNEP, including Health Canada, Public Safety Canada, the CNSC, Environment Canada, Public Health Agency of Canada, Foreign Affairs and International Trade Canada, NRCan and Transport Canada. All departments and agencies are responsible for developing, maintaining and implementing their own organization-specific emergency response plans that align with and support the objectives of the FERP and FNEP (some of these are described below). The federal Minister of Public Safety is responsible for exercising leadership relating to emergency management in Canada by coordinating emergency management activities, among government institutions and in co-operation with the provinces and other entities..

The FNEP has direct inputs from the local municipal and provincial governments, the licensee, and federal departments and agencies allowing the various jurisdictions and organizations that have responsibilities for aspects of nuclear emergency preparedness to discharge their responsibilities in a co-operative, complementary and coordinated manner. Provincial annexes to the FNEP, currently being updated, describe interfaces between the Government of Canada and the provincial emergency management organizations in those provinces with NPPs or that have ports hosting foreign nuclear-powered vessels (Quebec, Ontario, New Brunswick, British Columbia and Nova Scotia).

The FNEP cites Health Canada's *Canadian Guidelines for Intervention During a Nuclear Emergency*, which address protective measures for the public, including evacuation. The guidelines, developed by Health Canada, recommend evacuation of the population if the projected whole-body dose exceeds 50 mSv in seven days. These guidelines are currently being updated based on the latest guidance from the ICRP and IAEA (Basic Safety Standards).

Annex 16.1(e) describes the provisions of the FNEP in more detail.

In addition to managing the FNEP, Health Canada's Radiation Protection Bureau is responsible for operating various radiological monitoring networks: the Fixed Point Surveillance Network, the Canadian Radiation Monitoring Network (see subsection 15(c)) and the radiation monitoring stations within the Canadian portion of the Comprehensive Nuclear Test-Ban Treaty International Monitoring System. See appendix C in Canada's report to the Second Extraordinary Meeting of the CNS for details.

The Radiation Protection Bureau also operates radiological sample analysis laboratories (including mobile facilities), contamination monitoring capabilities (including portal monitors), and internal and external dosimetry programs for exposed individuals (including emergency workers). It provides radiation protection guidance and expertise and organizes emergency exercises, as well as administering two emergency preparedness committees within the framework of the FNEP.

Environment Canada–Canadian Meteorological Centre works closely with Health Canada to provide a suite of atmospheric modelling capabilities for nuclear emergency management, ranging from local to global atmospheric modelling capabilities, including dispersion and trajectory modelling, and forward/backward modelling. These products are provided to the provincial science groups through the federal technical representatives, as defined in the federal and provincial nuclear emergency plans. As described in the FNEP, other federal institutions, including the Department of National Defence and NRCan, also contribute specific scientific and technical expertise and capabilities necessary to manage the actual or potential radiological consequences of a nuclear emergency. Health Canada maintains an all-hazards plan that describes its response framework to a range of emergencies that could impact its specific areas of responsibility, and is currently developing a specific nuclear emergency annex.

Emergency plans of federal departments and agencies

The CNSC has its own nuclear emergency response plan that clearly defines and enables its roles within the context of the FNEP. The CNSC participates directly in emergency planning activities with other FNEP core agencies. The CNSC also participates in some exercises to practise discharging its own emergency-related responsibilities. A general description of the CNSC's role in emergency preparedness is provided in annex 16.1(e). The CNSC also has a well-developed and mature nuclear emergency management program, based on the 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 Act and 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 co-operate in emergencies and incidents involving nuclear substances, in accordance with the FNEP, relevant federal legislation, and formal administrative arrangements.

Review of federal emergency preparedness in light of Fukushima

In response to Fukushima, many Canadian federal departments activated their emergency plans and emergency operations centres. In addition, the multi-departmental Technical Assessment Group under the FNEP was convened to provide coordinated situational assessment to the government response. The CNSC activated its nuclear emergency organization immediately following the notice of the Fukushima accident. For 23 days, CNSC staff worked around the clock in the CNSC Emergency Operations Centre to monitor and assess the situation in Japan and contribute to the strategy for the Canadian response. The CNSC's nuclear emergency organization worked in close collaboration with Health Canada, other Government of Canada departments and agencies, and nuclear regulators from the United States, the United Kingdom and France, as well as with the IAEA.

Health Canada and Public Safety Canada, as well as the CNSC and other partners involved in the response to the Fukushima incident, have undertaken comprehensive lessons-learned reviews within their areas of responsibility, with a focus on issues of relevance to offsite emergency response in Canada. As mentioned in subsection 16.1(a), Public Safety Canada conducted a whole-of-government review to identify recommendations, corrective actions and best practices.

Health Canada, with input from its federal and provincial coordinating committees for nuclear emergency management, addressed the post-Fukushima situation by:

- undertaking a lessons-learned review of the response to Fukushima, focusing on the scientific assessment and timely decision making for offsite emergency response and implications for the update of the FNEP
- revising federal guidance for intervention during a nuclear emergency
- engaging federal, provincial and international partners to address areas of improvement in offsite emergency management

The CNSC conducted its review through its Fukushima Task Force. The Task Force concluded that there are no nuclear emergency response issues that require immediate action at the federal level. The Task Force concluded that the FNEP is both mature and comprehensive and that the revision of the FNEP in 2012, mentioned above, improved it further and addressed various lessons learned from Fukushima. The major findings relevant to the federal aspects of emergency preparedness were described in subsection 16.1(a) in the context of interaction among federal, provincial and onsite emergency preparedness.

The Task Force found that provincial (and federal) nuclear emergency planning authorities primarily address preparedness and response, but do not fully address recovery phase guidelines and procedures in their emergency plans. Aspects of the FNEP that cover recovery are described in annex 16.1(e).

16.1 (f) Exercises and drills

Emergency exercises confirm adequate implementation of onsite and offsite provisions in nuclear emergency response plans. Emergency drills are designed to provide training opportunities for enhancing the abilities of involved parties to respond to emergency situations and to protect public health and safety during an event at 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.

The frequency of emergency exercises at NPPs is defined in CNSC regulatory document *Testing the Implementation of Emergency Measures* (RD-353), which was added to operating licences as they were renewed during the reporting period. RD-353 states that licensees are directly responsible for training their personnel and involving them in emergency exercises, and for appointing qualified personnel to their emergency teams. A schedule for both emergency drills and emergency exercises should be established every year to ensure that all responders, including alternates, have the opportunity to practise the required skills on a regular basis. All emergency exercise objectives should be addressed over a five-year period, with a full-scale emergency exercise every three years.

CNSC staff evaluate the full-scale emergency exercises at the NPPs to ensure that licensees are effectively managing and implementing their emergency responses (specifically, the onsite provisions). During the reporting period, six such exercises were evaluated; the CNSC's conclusions are briefly summarized as follows:

- Within the scope of the Pickering exercise (November 2010), OPG staff demonstrated preparedness and competence in dealing with a simulated accident and good exchange of information at the federal, provincial and local levels.
- During the Gentilly-2 exercise, Hydro-Québec staff demonstrated that they meet the majority of the emergency management requirements in the licence to operate.
- During the Point Lepreau exercise (March 2012), NBPN staff demonstrated satisfactory performance (although there was no testing of emergency response capabilities inside the protected area because of the refurbishment activities at that time).
- The inspection team onsite at Darlington (June 2012) concluded that OPG demonstrated preparedness and competence in dealing with such an exercise. The inspection team for a second exercise at the Emergency Worker Centre in Orono also concluded that OPG staff demonstrated their competence by fulfilling their role in the operations of this centre.
- During the exercise at Bruce (October 2012), Bruce Power staff demonstrated their ability to respond to a series of severe-weather simulated events affecting the NPP and showed effectiveness of the emergency management program.

The CNSC also observes emergency exercises to confirm adequate implementation of offsite provisions in nuclear emergency response plans.

In some cases, the municipalities, the provinces and the CNSC will also participate in the exercises with NPP licensees (to a certain degree). The CNSC participates in emergency exercises to practise discharging its own emergency-related responsibilities and to ensure communication lines are in place and in a state of readiness. Other federal departments may participate to similarly practise their responsibilities.

The CNSC Fukushima Task Force found that federal and provincial nuclear emergency planning authorities had not been making regularly planned, full-scale NPP-focused exercises a priority. There had been a general reduction in the frequency of full-scale NPP-focused exercises at the provincial and federal levels. Although all provincial and federal plans that were reviewed appeared to be satisfactory, the implementation, and thus the capability to respond, had generally not been tested in an exercise for several years. For example, prior to the recent exercise in New Brunswick in March 2012 (described in annex 16.1(f)), the most recent provincial, full-scale nuclear emergency exercise was in 2007. While various organizations and jurisdictions have routinely exercised their plans and capabilities in a range of exercises, the effectiveness of all arrangements for an NPP (federal, provincial, municipal, operator) has not been tested in a national, full-scale exercise since 1999. The need for an ongoing nuclear emergency exercise series involving all jurisdictions was identified and endorsed as part of the post-Fukushima improvement process.

The CNSC Fukushima Task Force recommended that the effectiveness of the FNEP should be tested in a full-scale, national exercise more frequently. The Fukushima review during the IRRS follow-up mission to Canada made a similar finding. See subsection 16.1(a) and recommendation RF8 for more details. Efforts are underway to plan for a national-scale exercise of the updated FNEP in May 2014 at Darlington which will validate the full integration of the FNEP, the FERP, the PNERP, OPG's Consolidated Nuclear Emergency Plan and the plans of other non-governmental organizations.

The emergency exercises conducted during the reporting period are described in more detail in annex 16.1(f), along with those planned for the next reporting period.

16.2 Information to the public and neighbouring states

16.2 (a) Measures for informing the public during a national nuclear emergency

As stated in subsection 9(d), Class I facility licensees are required to have a program to inform persons living in the vicinity of the site of the general nature and characteristics of the anticipated effects on the environment and the health and safety of persons that may result from the activity to be licensed. As described in subsection 9(d), CNSC regulatory document *Public Information and Disclosure* (RD-99.3) was published in 2012 and is being added to the existing licences to operate NPPs as they are renewed. The information to be disclosed would include the impact of natural events such as earthquakes, routine and non-routine releases of radiological and hazardous materials to the environment and unplanned events, including those exceeding regulatory limits. This, therefore, would cover severe accidents. The NPP licensees have public disclosure programs that already meet most of the requirements in RD/GD-99.3.

The provinces provide the public with direction on the need to undertake protective actions (through emergency bulletins), if required, during a nuclear emergency. The provinces inform all relevant stakeholders prior to issuing the emergency bulletins to the public.

During the reporting period, the public alerting system for NPPs in Ontario was enhanced with the installation of sirens for the contiguous zone (3 km) of Pickering and Darlington. 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 (10 km) is notified appropriately and in a timely manner.

For domestic nuclear emergencies impacting provinces or territories, provincial/territorial information centres will be the main sources of public and media information on aspects of emergency operations and protective actions.

At the federal level, the Federal Public Communications Coordination Group, led by Public Safety Canada's Communications Directorate, in accordance with FERP, will coordinate the federal government's communications response to the public, media and affected stakeholders in collaboration with the provinces/territories, as well as private sector stakeholders, as required. Federal government institutions will contribute information to this group according to their mandates. FNEP federal spokesperson(s) will present the federal position with respect to the nuclear emergency, according to the specific issues and in coordination with the provincial information centres. For emergencies occurring at licensed facilities, the facility operator and the CNSC will provide information about on-site conditions.

16.2 (b) International arrangements, including those with neighbouring countries

Canada participates in the IAEA International Nuclear Event Scale (INES) reporting system. Canada has excellent working relationships with the United States for the exchange of emergency preparedness expertise. In addition, Canada has signed the following three international emergency response agreements and ratified the two conventions listed.

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 co-operative measures to deal with peacetime radiological events involving Canada, the United States, or both countries. Co-operative measures contained in the FNEP are consistent with the joint plan.

Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency

Canada is a signatory of the IAEA's *Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency* (1986), which sets out an international framework for co-operation among countries and with the IAEA to facilitate prompt assistance and support in the event of nuclear accidents or radiological emergencies. It requires countries to notify the IAEA of their available experts, equipment or other materials they could offer in assistance. In case of a request for assistance from an affected country, each country decides whether it can offer the requested assistance. The IAEA serves as the focal point for such co-operation by channelling information, supporting efforts, and providing its available services. The agreement sets out how assistance is requested, provided, directed, controlled and terminated. Since 2012, Health Canada and AECL have registered their radiological biodosimetry capabilities with the IAEA's Response and Assistance Network (RANET) in support of this convention.

Convention on Early Notification of a Nuclear Accident

Canada is a signatory of the IAEA's *Convention on Early Notification of a Nuclear Accident* (1986), which establishes a notification system for nuclear accidents having the potential for international trans-boundary release that could be of radiological safety significance for another country. The accident's time, location, radiation releases and other data essential for assessing the situation must be reported, both directly to the IAEA and to other countries either directly or through the IAEA.

16.3 Emergency preparedness for Contracting Parties without nuclear installations

This part of article 16 does not apply to Canada.

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

Part D
Safety of Installations

Part D of chapter III consists of three articles:

Article 17 – Siting
Article 18 – Design and construction
Article 19 – Operation

Article 17 – Siting

> Each Contracting Party shall take the appropriate steps to ensure that appropriate procedures are established and implemented:
>
> (i) for evaluating all relevant site-related factors likely to affect the safety of a nuclear installation for its projected lifetime;
>
> (ii) for evaluating the likely safety impact of a proposed nuclear installation on individuals, society and the environment;
>
> (iii) for re-evaluating as necessary all relevant factors referred to in sub-paragraphs (i) and (ii) so as to ensure the continued safety acceptability of the nuclear installation;
>
> (iv) for consulting Contracting Parties in the vicinity of a proposed nuclear installation, insofar as they are likely to be affected by that installation and, upon request providing the necessary information to such Contracting Parties, in order to enable them to evaluate and make their own assessment of the likely safety impact on their own territory of the nuclear installation.

In Canada, the term "siting" comprises site evaluation and site selection. The applicant's evaluation and selection of a site is not a regulated activity. However, the resultant site selection case is assessed as part of the application for a licence to prepare a site. The framework and process for issuing a licence to prepare a site for an NPP are described in subsection 7.2(ii), with details in subsection 7.2(ii)(b). An environmental assessment (EA) has historically been initiated following an application for a licence to prepare a site or a licence application/amendment for a life extension project for an existing facility. EAs identify whether a specific project is likely to cause significant environmental effects, ensuring that potentially significant adverse effects are identified and mitigated to the extent possible. See subsection 17(ii)(a) for a more detailed description of EAs.

During the previous reporting period, OPG conducted a number of site evaluation studies for the Darlington new-build project. The EA, which followed during the more recent reporting period, concluded that the project was not likely to result in significant adverse effects. Following the Government of Canada's acceptance of the EA, OPG was issued a licence to prepare the site in August 2012. Details are provided in annex 17.

An EA was also conducted for the life extension project for the existing Darlington units – see subsection 17(iii)(b) for details.

Under the CEAA (2012), an EA is initiated following an application for a licence to prepare the site for a new NPP or small modular reactor. Life extension projects no longer require EAs.

As outlined in the CNSC document *Site Evaluation for New Nuclear Power Plants* (RD-346), prior to the triggering of the EA and licensing processes, the applicant is expected to use a robust process to characterize proposed sites over the full lifecycle of the facility and then develop a fully documented defence of the site selection. This case forms the backbone for submissions in support of the EA and the application for a licence to prepare the site, which is reviewed by the CNSC and other applicable federal authorities.

Level of NPP design information expected to demonstrate site suitability

Under the CEAA (2012), the decisions made by the Commission on an application for a licence to prepare a site for a new NPP may be made with high-level facility design information from a range of reactor designs. The design information provided by the applicant must be credible and sufficient to adequately bound the evaluations of environmental effects and site suitability from a range of reactor designs that might later be deployed at the site. See annex 17 for an example.

The bounding design parameters must contain sufficient information to describe the NPP–site interface and take into consideration the characteristics of the proposed site. The underpinning of the bounding approach is that the environmental effects of the reactor design eventually selected for construction should be less than the bounding effects assessed in the site evaluation and the environmental impact statement (EIS), which the applicant prepares as part of the EA process.

Although CNSC accepts high-level information in support of the site evaluation case, there is an increased level of regulatory scrutiny during the construction and operation licensing processes, in order to validate the claims made. At the licence to construct application phase, the applicant will be expected to submit detailed design information verifying the evaluations presented previously remain valid. If the level of information provided at the outset is limited, however, there is a greater likelihood that fundamental barriers to licensing will appear during the review process for a licence to construct. Thus, it is in the best interest of the applicant to make its submissions as complete as possible at the outset.

The required level of design information for a site evaluation includes:

- a technical outline of the facility layout (preliminary or schematic in nature)
- qualitative descriptions of all major structures, systems and components (SSCs) that could significantly influence the course or consequences of principal types of accidents and malfunctions
- qualitative descriptions 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)

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

For site evaluation carried out in support of licensing (including emergency planning purposes), the CNSC expects severe accident sequences to be addressed. The severe accident sequences include, where applicable, simultaneous multi-unit events, with loss of the electrical grid/station blackout events, and events with a simultaneous loss of offsite power, with loss of normal access to the ultimate heat sink for an extended period of time.

A description of specific (out-of-reactor) criticality events must be provided, showing that these events do not violate criteria established by international standards and national guidance as triggers for public evacuation.

If the applicant chooses to pursue a licence to prepare a site without choosing a final NPP technology, the activities permitted under the issued licence to prepare the site would be limited to site preparation activities that are independent of any specific reactor technology (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 an applicant to apply facility design information to its site selection case, a fundamental expectation of the CNSC is that the applicant will demonstrate the capability of a "smart buyer". This means that it will be expected to demonstrate a clear understanding of the technologies it is proposing to use and the basis from which the site selection case is developed.

Site evaluation criteria – General

The information provided in an application for a licence to prepare a site is assessed against the criteria described in the CNSC document *Site Evaluation for New Nuclear Power Plants* (RD-346). RD-346 adapts the tenets set forth by the IAEA safety requirements document *Site Evaluation for Nuclear Installations* (NS-R-3) and its associated guides. RD-346 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. Specifically, 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(c)) 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.

17 (i) Evaluation of site-related factors

The CNSC licence application guide for a licence to prepare a 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)(b) 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, tornadoes, ice storms or other severe weather, and earthquakes. The return periods for severe weather, flood or wind are not prescribed. However, the applicant is expected to propose adequate periods based on criteria identified in IAEA documents that are referenced in *Site Evaluation for New Nuclear Power Plants* (RD-346) (e.g., IAEA safety guide NS-G-3.4 and safety standards NS-G-1.5, NS-G-3.2, NS-G-3.4 and NS-G-3.5).

RD-346 requires the applicant to consider climate change when evaluating the potential impact of these phenomena. An example of this consideration for the Darlington new-build project is provided in annex 17.

Site-related factors also include the proximity of the site to one or more of the following:

- railroad tracks (possibility of derailments and the release of hazardous material)
- flight paths for major airports (possibility of airplane crashes)
- toxic chemical plants (possibility of toxic releases)
- 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.

Licensees also have to perform a site-specific external hazards screening to identify other hazards that may require a PSA or a bounding analysis. Further, the licensees must consider combinations of events, including consequential and correlated events. Examples of consequential events include external events (such as a cooling water intake blockage caused by severe weather or a tsunami caused by an earthquake) and internal events (such as a fire caused by an earthquake). Examples of correlated events include heavy rainfall concurrent with a storm surge or high winds caused by a hurricane.

Consequential events are considered in the PSAs (see subsection 14(i)(d)). Selected cases are documented in the NPP safety reports (see subsection 14(i)(c)).

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. 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 a site, currently being drafted, will also elaborate upon the criteria for evaluating the impact of the NPP on the surrounding population and the environment.

Prior to the CNSC's issuance of a site preparation licence, a positive decision regarding an EA is required. The EA process evaluates the effects of the project lifecycle of a proposed NPP on the environment. The CNSC separately evaluates the licence applicant's proposed measures to protect individuals, society and the environment, 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).

Licensee performance under the “environmental protection” safety and control area is also assessed annually for all operating NPPs in the *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants*. This safety and control 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. See appendix F for a full definition of the CNSC safety and control areas (table F.1) and for the performance ratings of the licensees during the reporting period (table F.2).

Subsection 15(c) describes particular provisions for controlling and monitoring radiological releases to the environment, as well as the actual releases during the reporting period.

17 (ii) (a) Environmental assessment

The NSCA and its regulations give the CNSC broad authority for protection of the environment. A significant component of any licensing decision is an assessment of the environmental impacts of the project. In parallel, the CEAA also requires an EA of designated nuclear projects. With the promulgation of the CEAA (2012), which replaced the CEAA (1992), the CNSC became the sole regulatory authority for EAs of nuclear-related designated projects. When an EA is triggered, the CNSC must ensure that both NSCA and CEAA requirements are met. The EA process under the CEAA (2012) is described in annex 17(ii)(a).

For nuclear-related projects, in accordance with the CEAA (2012), the scope of factors to be taken into account is determined by the CNSC and must include:

- the environmental effects of the designated project, including the environmental effects of malfunctions or accidents that may occur in connection with the designated project and any cumulative environmental effects that are likely to result from the designated project in combination with other physical activities that have been or will be carried out
- the significance of the effects identified above
- comments from the public that are received in accordance with the CEAA
- mitigation measures that are technically and economically feasible and that would mitigate any significant adverse environmental effects of the designated project
- the requirements of the follow-up program with respect to the designated project
- the purpose of the designated project
- alternative means of carrying out the designated project that are technically and economically feasible and the environmental effects of any such alternative means
- any change to the designated project that may be caused by the environment
- the results of any relevant study conducted by a committee established under section 73 or 74 of the CEAA
- any other matter relevant to the EA that the responsible authority requires to be taken into account

In addition, the CEAA (2012) states that “The environmental assessment of a designated project may take into account community knowledge and Aboriginal traditional knowledge.”

The CEAA (2012) provides opportunities for public participation throughout the EA process. For example, the public is always provided with an opportunity to comment on a draft of the EA report. The breadth and timing of additional public participation is at the discretion of the CNSC and may include a variety of proposed activities such as review of EA documents, 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 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 size, 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.

Specifically, the safety analysis report contains sections with the following information:

- demographics
- weather experience
- seismicity
- neighbouring facilities
- air and rail transport corridor activity

RD-346 further stipulates that the evaluation of site suitability includes consideration of:

- site characteristics that could have an impact on the public or on the environment
- population density, distribution and other characteristics of the protective zone that may have an impact on the implementation of emergency measures or on the evaluation of risk to individuals, the general population and the environment
- the effects of natural or human-induced external events

If the site evaluation indicates safety concerns that design features, site protection measures, or administrative procedures cannot remedy, the site is deemed unacceptable. The site evaluation includes:

- evaluation against safety goals
- consideration of evolving natural and human-induced factors
- evaluation of the hazards associated with external events
- determination of the potential effects of the NPP on the environment
- consideration of projected population growth in the vicinity of the site along with emergency planning that takes those projections into account

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

The potential 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 (see annex 17(ii)(a)).

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 OPG for its Darlington new-build project. A detailed description of the outreach activities, which included Aboriginal consultation, is provided in subsection 9(c).

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 the local environment, include:

- new insights from updated hazard studies
- 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.

The NPP operating licence condition that cites CNSC document *Reporting Requirements for Operating Nuclear Power Plants* (S-99) requires licensees to regularly submit, to the CNSC, certain reports that describe the effects of the NPP on the environment. For example, S-99 requires the safety analysis report to be updated and re-submitted every three years. This update includes consideration of any relevant new techniques or information, which could include new data or insights related to external events. Another required report is an annual report 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 that the public legal limit in Canada for effective dose from the operation of NPPs is not exceeded.

The NPP operating licences also cite CNSC document *Probabilistic Safety Assessment for Nuclear Power Plants* (S-294). S-294 requires a PSA for each NPP, including 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)(d).

The measures undertaken by the NPP licensees to re-evaluate and address site-related factors in response to Fukushima are described in subsection 17(iii)(c) below. Other specific examples that are not related to Fukushima lessons learned are provided in annex 17(iii)(a).

17 (iii) (b) Results of environmental assessments for life extension projects

An assessment of the environmental effects of life extension projects helps ensure the continued protection of the environment during the operation of NPPs. During the reporting period, a screening-level EA under the CEAA (1992) was completed for the life extension of Darlington. The CNSC determined that the project was not likely to cause significant adverse effects on the environment, taking into account identified mitigation measures related to aspects such as aquatic biota, water quality and air quality. Refer to subsection D.2 of chapter I and subsection 14(ii) for more information on life extension projects.

17 (iii) (c) Re-evaluation of site-related factors in response to Fukushima

As part of the follow-up to Fukushima, the licensees examined events more severe than those that have historically been regarded as credible. These events typically include earthquakes, floods, extreme weather events (e.g., high winds and heavy rain falls) and events caused by human activities (e.g., explosions) and their impacts on the NPPs. Specifically, the NPP licensees reconfirmed that the risk posed to Canadian NPPs from tsunamis is negligible. Nevertheless, NRCan conducted a preliminary probabilistic tsunami hazard assessment for Canada. As the licensee for the only coastline NPP in Canada (Point Lepreau), NBPN elected to further study the tsunami hazard to provide a high degree of assurance that the tsunami risk remains low. This work is in progress.

Upon review, the CNSC Fukushima Task Force reconfirmed the robustness of Canadian NPPs to withstand large external hazards. However, the Task Force concluded that the screening of external hazards and bounding analyses are in different states of development for each NPP (linked to the fact that some NPPs will not be in full compliance with S-294 until 2014).

The CNSC Fukushima Task Force confirmed that the NPPs that were reassessed as part of refurbishment activities were reviewed for external hazards and that their design bases are, to the extent practicable, in line with modern standards and practices. See subsection 14(i)(d) for additional information on external hazard assessments conducted for life extension.

For NPPs that have not been refurbished, the magnitudes of the external events considered in the designs comply with the standards applicable at the time of original licensing and are generally very conservative. However, the rationale for the magnitudes selected for beyond-design-basis hazards was not documented adequately or consistently for all the NPPs that were not refurbished. Further, the scope of the assessments and event magnitudes considered were below modern international best practice in some cases, although there are no external events requiring immediate action by the CNSC or licensees.

The CNSC Fukushima Task Force recommended that the licensees should conduct more comprehensive assessments of site-specific external hazards to demonstrate that:

- considerations of magnitudes of design-basis and beyond-design-basis external hazards are consistent with current best international practices
- consequences of events triggered by external hazards are within applicable limits

The licensees have completed various tasks in response to this recommendation, including reviewing the bases of external events, completing or updating PSAs and expanding their application to analyze site-specific, external hazards. NPP licensees have submitted to the CNSC their methodologies on external hazards screening and bounding analysis. Details on the progress at each NPP regarding PSA are provided in annex 14(i)(d).

For more detailed information on Canada’s re-evaluation of site-related factors in response to Fukushima, refer to Canada’s report to the Second Extraordinary Meeting of the CNS.

17 (iv) Consultation with other contracting parties likely to be affected by the installation

Canadian legislation and process (in particular, the CEAA and its regulations, and the federal EA and review process) do not obligate applicants of domestic NPPs that could affect the United States to consult with American jurisdictions or the American public regarding the proposed siting of the NPP. However, the CEAA (2012) requires that changes to the environment by a project outside Canada be assessed. Representatives or individuals from other jurisdictions also have the opportunity to participate in the federal EA process, as well as in the CNSC's licensing process, as intervenors.

In addition, the Government of Canada and the U.S. Government, in co-operation 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 U.S. Nuclear Regulatory Commission have a long practice of co-operation and consultation since the 1950s. In 1996, they entered into a bilateral administrative arrangement for co-operation 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.

Article 18 – Design and Construction

> Each Contracting Party shall take the appropriate steps to ensure that:
> (i) the design and construction of a nuclear installation provides for several reliable levels and methods of protection (defense in depth) against the release of radioactive materials, with a view to preventing the occurrence of accidents and to mitigating their radiological consequences should they occur;
> (ii) the technologies incorporated in the design and construction of a nuclear installation are proven by experience or qualified by testing or analysis;
> (iii) the design of a nuclear installation allows for reliable, stable and easily manageable operation, with specific consideration of human factors and the man-machine interface.

All operating NPPs in Canada are CANDU designs. CANDU reactors feature heavy-water coolant and moderator, as well as fuel channel and fuel bundle, designs that enable online fuelling. Some specific CANDU design features related to defence in depth are described in annex 18(i). The first and second Canadian reports contain extensive information on the evolution of the design and construction of CANDU-type NPPs. Canada sponsors significant R&D that addresses the area of design and construction; see appendix E for details.

Activity related to the design and construction of new NPPs in Canada was ongoing during the reporting period. Background information on licence applications related to new-build projects in Canada is provided in subsection D.3 of chapter I. During the reporting period, as a follow-up to the EA associated with its licence to prepare the site for the Darlington new-build project, OPG assessed potential cooling water systems (see annex 17 for details). OPG completed a number of site readiness projects include site cleanup, termination of services and abandonment or relocation of existing buildings. Geotechnical investigations and geophysical surveys were also completed in 2010. In 2012, OPG engaged Westinghouse and SNC-Lavalin/Candu Energy to prepare detailed construction plans, schedules and cost estimates for the AP1000 and EC6 reactor designs, respectively. The vendor submissions are currently being analyzed. Formal reports will be forwarded to the Province of Ontario in the next reporting period to help inform the province’s decision to proceed with new-build projects.

The general CNSC framework and process for issuing a licence to construct a Class IA nuclear facility (of which an NPP is an example) are described in subsection 7.2(ii). In response to existing, and in preparation for potential, new-build licence applications, the CNSC continues to update its design requirements for NPPs, participate in the Multinational Design Evaluation Programme (MDEP), and conduct pre-project vendor design reviews. These activities are described in the following subsections. The CNSC is also developing staff work instructions to coordinate its review of submissions of applications for a licence to construct an NPP. Staff work instructions are described in more detail in subsections 7.2(ii)(a) and 8.1(d).

Specific design requirements and licensee provisions related to defence in depth, proven technologies, and reliable, stable and easily manageable operation are described in subsections 18(i), 18(ii) and 18(iii), respectively, for the currently operating NPPs and for potential new-build projects.

Updating design requirements for new-build projects

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.

CNSC regulatory document *Design of New Nuclear Power Plants* (RD-337) sets out expectations for the design of new, water-cooled NPPs. To a large degree, RD-337 represents the CNSC's adoption of the tenets set forth in the IAEA document *Safety of Nuclear Plants: Design* (NS-R-1) and the adaptation of those tenets to align with Canadian practices. To the extent practicable, RD-337 sets technology-neutral requirements related to defence in depth, use of proven technology and easily manageable operation of NPPs (e.g., reliability, human factors). Along the lines of IAEA document NS-R-1, RD-337 requires the concept of defence in depth be applied to all organizational, behavioural and design-related safety and security activities to ensure that they are subject to overlapping provisions. Defence in depth is to be applied throughout the design process and operation of an NPP. The scope of RD-337 goes beyond that of IAEA NS-R-1 in addressing the interfaces between NPP design and other topics, such as environmental protection, safeguards, and accident and emergency response planning. Additional details on RD-337 are provided in annex 18.

The CNSC's regulatory review of an application for a licence to construct will include a clause-by-clause assessment of the proposed design against the requirements in RD-337.

Upgrading designs of existing NPPs

For existing NPPs, the licensees have continuously made design improvements even though many of the updated design requirements were established after the NPPs were built. Although RD-337 is not cited in the licences to operate existing NPPs, design changes have been made to address other new standards and requirements added to the operating licences, on an ongoing basis, when the licences are renewed or amended (as described in subsection 7.2(ii)(d)).

Furthermore, life extension projects have provided an opportunity to upgrade the existing CANDU NPPs to align with RD-337 and other new standards, whether or not they are cited in the licence to operate. Integrated safety reviews (ISRs) 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. Integrated implementation plans identify strengths and shortcomings for each of the safety factors identified in the ISR, rank the shortcomings in terms of safety significance, and prioritize corrective measures, including design and other safety improvements. The design improvements that have been effected in Canada as part of life extension have addressed the various factors being addressed in subsections 18(i), (ii) and (iii) of this article. The general regulatory approach to life extension is described in subsection 7.2(ii)(d) and the safety assessment aspects of ISR are described in subsection 14(i)(g). Some examples of design changes to existing NPPs, including those that were part of refurbishment, are given in annex 18(i) in the context of improvements to defence in depth.

Response to Fukushima – Design considerations

The CNSC is revising its regulatory requirements and guidance for design in light of the lessons learned from Fukushima. The CNSC is reviewing and amending, as necessary, regulatory documents to incorporate specific design-related findings of the CNSC Fukushima Task Force for both existing and new NPPs. Those amendments will update selected design-basis and beyond-design-basis requirements and expectations, including those for:

- external hazards and the associated methodologies for assessment of magnitudes
- probabilistic safety goals
- complementary design features for both severe accident prevention and mitigation
- passive safety features
- fuel transfer and storage
- design features that would facilitate accident management

The specific regulatory documents being amended and/or developed to address design lessons learned from Fukushima are listed in subsection 7.2(i)(b). The regulatory framework for human and organizational factors for existing NPPs and new-build projects is also evolving, in part to address lessons learned from Fukushima. See subsection 12(j) and annex 18 for details.

The CNSC is preparing for the assessment of potential applications for small reactors; see annex 7.2(i)(c) for a description of the regulatory framework for small reactors.

Multinational Design Evaluation Programme

The CNSC plays an active role in MDEP, which has representatives from 10 countries, with the OECD's Nuclear Energy Agency (NEA) providing a technical secretariat function. MDEP aims to harmonize 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

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

- design-specific safety issues and activities surrounding 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 an 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.

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. The CNSC has developed staff work instructions 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 Web site. The phases of vendor pre-project design reviews and the status of specific reviews, are described in annex 18.

The CNSC has found the vendor pre-project design reviews to be extremely valuable – not only as part of preparing for future licence submissions, but also in investigating new design issues and their potential impacts on the regulatory framework. This process, in parallel with MDEP activities, has contributed significantly to CNSC readiness for future licensing activities. OPG also found that the vendor pre-project design reviews were helpful for its application for a licence to prepare the site for the Darlington new-build project, particularly for the selection of technologies on which to base the bounding approach.

CANDU design-related activities

Candu Energy is developing the EC6 reactor, which is a Generation III design that represents an evolution from the CANDU 6 reference design (Qinshan, China). EC6 is intended to meet or exceed current regulatory design requirements, such as those in CNSC regulatory documents RD-337 and *Safety Analysis for Nuclear Power Plants* (RD–310). In particular, this evolution has resulted in the addition of a new safety system (emergency heat removal system) and the addressing of requirements related to safety goals, severe accidents, single failure criterion, system classification, containment design and malevolent acts, and seismic event frequency. Candu Energy's response to Fukushima included a careful review of the EC6 design to ensure that its design takes maximum advantage of the lessons learned from Fukushima and the national and international reviews.

Candu Energy has also been involved in the overall industry response to the Fukushima event to reassess the safety of the existing CANDU reactors. Candu Energy has contributed to the work to determine if changes in design, equipment or processes are needed, based on the Fukushima lessons learned.

Nuclear code of conduct for NPP vendor countries

Canada continued its participation in the initiative sponsored by the Carnegie Endowment for International Peace to develop a Nuclear Power Plant Exporters Principles of Conduct (formerly called Vendor Code of Conduct). Its purpose is to complement national laws and regulations, international laws and norms, and the recommendations of institutions, such as the IAEA, that promote the peaceful use of nuclear technology as a safe, secure, reliable and efficient source of energy. During the reporting period, meetings to finalize the principles of conduct occurred in Tokyo, Pittsburgh, Moscow and Brussels. The document spells out some important principles for NPP exports: safety, health, radiological protection, physical security, environmental protection and the handling of spent fuel and nuclear waste, compensation for nuclear damage, nonproliferation and safeguards and ethics.

18 (i) Implementation of defence in depth in design and construction

To ensure a low probability of failures or combinations of failures that would result in significant radiological consequences, design for the defence-in-depth approach considers the following:

- conservative design and high quality of construction to minimize abnormal operation or failures

- provision of multiple physical barriers that prevent the release of radioactive materials to the environment
- provision of multiple means for each of the basic safety functions (e.g., reactivity control, heat removal, confinement of radioactivity)
- use of reliable, engineered protective devices in addition to the inherent safety features
- supplementation of the normal control of the NPP by automatic activation of safety systems or by operator actions
- provision of equipment and procedures to detect failures, along with backup accident prevention measures 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 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.

The designs of Canada’s NPPs, which are all CANDU reactors, include several features that prevent accidents and can help mitigate impacts should an accident occur. The reactors have a large inventory of cool water surrounding the fuel, capable of providing passive cooling, such that adequate time is available for long-term mitigation of accidents. Also, CANDUs have two groups of independent, physically separated, and diverse backup power and cooling water systems.

Some of the criteria that have guided the design of the currently operating NPPs in Canada and contributed to defence in depth are described in conjunction with the safety analysis criteria (in subsection 14(i)(c)). Specific design criteria and requirements are found in some of the CSA standards cited in the licences to operate the existing NPPs, such as:

- *General Requirements for Pressure Retaining Systems and Components in CANDU Nuclear Power Plants* (N285.0)
- *Fire Protection for CANDU Nuclear Power Plants* (N293)

As well, RD-337 contains updated requirements related to defence in depth (see annex 18) that will be applied to new-build projects and considered for refurbishing reactors. The existing NPPs made various design improvements to enhance defence in depth during the reporting period. In particular, design improvements were evaluated and completed for NPPs undergoing or considering refurbishment. Based on systematic reviews against modern standards, NPP licensees made modifications during refurbishments that reduce the likelihood and consequences of severe core damage and a large release of radioactive materials.

The refurbishments of Bruce Units 1 and 2 and Point Lepreau for life extension and continued operation were completed during the reporting period. Pickering B also prepared for an incremental life extension. Some examples of improvements to defence in depth in CANDU reactors currently operating in Canada, including those carried out for life extension projects, are provided in annex 18(i).

The refurbishment of Point Lepreau was particularly interesting because the Fukushima accident occurred during its refurbishment. Several of the potential safety improvements recommended by the CNSC Fukushima Task Force had been, or were already being, implemented at Point Lepreau as part of the planned refurbishment activities.

During the reporting period, CNSC staff deemed the level of defence in depth at all Canadian NPPs to be acceptable. CNSC staff also specifically assessed the level of defence in depth of existing NPPs in light of Fukushima. The CNSC Fukushima Task Force concluded that the design basis for Canadian NPPs is comprehensive and that the NPPs meet the design requirements. The Task Force also concluded that the risk to the Canadian public from beyond-design-basis accidents at NPPs is very low. Given the design features and defence in depth described above, adequate time would be available for long-term mitigation of a beyond-design-basis accident. Although the risk of an accident is very low, NPP operators are implementing several modifications to improve their NPPs' abilities to withstand prolonged losses of power and other challenges, such as the loss of all heat sinks. The CNSC is taking action and revising regulatory requirements, including those for the design of new NPPs. Additional details on the assessment of defence in depth based on the lessons learned from Fukushima are provided in annex 18(i).

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 design and safety analysis information in the safety analysis report and the QA program for design and safety analysis.

The CANDU design criteria and requirements include design and construction of all SSCs to follow the best applicable code, standard or practice and to be confirmed by a system of independent audit.

In particular, for pressure boundaries, existing NPPs meet the requirements of CSA document *General Requirement for Pressure-Retaining Systems and Components in CANDU Nuclear Power Plants* (N285.0), which is cited in their operating licences. The CNSC reviews the design against the requirements of the NSCA and the associated regulations and approves the classification using the requirements in CSA N285.0. The licensee then registers the design with an authorized inspection agency, which audits the fabrication of the design, inspects the construction/installation and tests, and countersigns the pressure test results.

An example of the application of state-of-the-art technology for CANDU is the research, development and implementation of passive autocatalytic hydrogen recombiners (PARs) for Canadian CANDU NPPs. See annex 18(ii) for details.

The licence to operate an NPP requires the licensee to update its safety analysis report at least once every three years. As stated in subsection 14(i)(c), 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. The safety analysis report must use or incorporate new methodologies, computer codes, experimental data, and R&D findings. As a result, many of the events in the safety analysis report are often re-analyzed in the updated version.

Licensees are also required by a condition in their operating licences to use safety analysis computer codes that have been validated in accordance with the requirements of CSA document *Quality Assurance of Analytical, Scientific and Design Computer Programs for Nuclear Power Plants* (N286.7).

Further, CNSC document *Safety Analysis for Nuclear Power Plants* (RD-310), which was being added to the licences to operate during the reporting period, stipulates the selection of computational methods or computer codes, models and correlations that have been validated for the intended applications. 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)(c).

Environmental qualification programs at Canadian NPPs also help to prove that safety and safety-related systems will operate as intended, insofar as they are relied upon to help prevent, manage and/or mitigate accidents. CNSC operating licences for NPPs cite CSA document *Environmental Qualification of Equipment for CANDU Nuclear Power Plants* (N290.13). The NPP licensees have 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. The CNSC monitors the progress of these programs, in addition to ongoing inspections of these systems.

For new-build projects, in addition to the criteria for existing NPPs (such as those found in CSA documents N285.0, N286.7 and N290.13), there are requirements in RD-337 for proving engineering practices and qualifying designs (see annex 18).

The safety analyses submitted in support of the application will also be assessed against the requirements in 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 human–machine interfaces throughout the entire life of an NPP to make sure the NPP is tolerant of human errors.

The consideration of human factors in design and the application of human factors in engineering are described in subsection 12(b). Specific activities undertaken by the CNSC to address human and organizational factors linked to lessons learned from Fukushima are described in subsection 12(j). Detailed design requirements in RD-337 that are related to human factors and the human–machine interface are provided in annex 18.

The following are two examples of the consideration of human factors and human–machine interface in the design of existing Canadian NPPs.

A high level of automation is incorporated into CANDU designs 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 that could cause a parameter to exceed normal operational limits or a safety system trip setpoint. The overall and specific designs of protection systems make sure that operator intervention is required only 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 human–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.

Requirements from RD-337 related to reliability, operability and human factors are described in annex 18.

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 NPP licensee programs relevant to this article – operations and maintenance – are assessed annually for all NPPs in the *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants*. The operations program is under the “operating performance” safety and control area, and the maintenance program is under the “equipment fitness for service” safety and control area. During the reporting period, all the licensees had “satisfactory” performance in both safety and control areas. See appendix F for a full definition of the CNSC safety and control 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 an NPP is predicated on the applicant having already demonstrated conformance with the requirements for siting, design and construction (as outlined in subsections 7.2(ii)(b), 7.2(ii)(c) and articles 17 and 18).

(See subsection 7.2(ii)(d) for additional details regarding information that an applicant is required to submit with an application for a licence to operate.) The granting of an initial licence to operate is based upon an appropriate safety analysis and a commissioning program demonstrating that the NPP, as constructed and commissioned, meets design and safety requirements.

General requirements related to deterministic safety analysis and PSA are described in subsections 14(i)(c) and 14(i)(d), respectively. The final safety analysis report submitted with an application for a licence to operate a new NPP will be assessed against the 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 NPP commissioning program are to determine that:

- the commissioning program is comprehensively defined and implemented to confirm that the SSCs important to safety and the integrated plant will perform in accordance with the design intent, safety analysis and applicable licensing requirements
- the operating procedures covering all operating and abnormal states have been validated to the maximum extent practicable
- the commissioning and operating staff have been trained and qualified to commission the plant and operate it safely, in accordance with the approved procedures
- the management system has been adequately defined, implemented and assessed to provide a safe, effective and high-quality working environment to perform and support the conduct of the commissioning program

For each phase of commissioning, the NPP management is expected to establish a set of commissioning control points (CCPs) to achieve a transparent, accountable and effective process to ensure that the prerequisites for the release of each CCP have been formally demonstrated.

Licensing CCPs are regulatory hold points, requiring prior authorization by the Commission or a person authorized by the Commission to proceed further in the commissioning program. Non-licensing CCPs are usually treated as witness points, observed by CNSC staff. Licensees are expected to exercise appropriate control of all CCPs. All applicable non-licensing CCPs must be satisfactorily completed as part of obtaining the release from the 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).

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 subsection 6(b) of the *Class I Nuclear Facilities Regulations*.

The safe operating limits satisfy regulatory requirements, standards and guidelines related to NPP design and operation, including defence-in-depth principles. Historically, these are implemented in operating manuals and impairment manuals (see subsection 19(iv)).

The full set of requirements for safe operation of a CANDU NPP includes:

- requirements on special safety systems and safety-related standby equipment or functions (e.g., set points and other limiting parameters, and availability requirements)

- requirements on process systems (e.g., limiting parameters, testing and surveillance principles and specifications, and performance requirements under abnormal conditions)
- prerequisites for removing special safety systems and other safety-related or process standby equipment from service

These requirements are derived from design-basis safety analyses that are described in the safety analysis report. The safety analysis examines the NPP's responses to disturbances in process 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 analyze in advance every potential state that could occur throughout the life of an NPP. Therefore, the analysis attempts to consider sufficient situations to define safe operating limits that encompass the expected variations in conditions at a reasonable level of system/equipment performance detail.

Operating limits for Canadian NPPs that have the greatest impact on safety are identified in the operating policies and principles (OP&P; see subsection 9(b)) document. Changes to these limits that may negatively impact safety require appropriate justification by operations support staff and are reviewed by the CNSC.

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. In the past, the licensees primarily used an OP&P to define relevant operational limits. Since the OP&P represents only a subset of the relevant limits, however, the licensees undertook a project to more fully define the SOE as a complete and comprehensive set of limits derived from the safety analysis through controlled processes. One of the initial outputs was the publication by COG of industry principles and guidelines for SOEs that integrate best practices and OPEX from Canadian NPPs.

For NPPs far advanced with their SOE projects, the SOE limits have been checked against OP&P limits. Only minor discrepancies have been found to date. Full implementation of the SOE project is not expected to lead to significant changes to limits currently listed in the OP&P. The work at each NPP is ongoing. An industry SOE working group produced its final report in 2012 to rationalize the systems included in the SOE. This report was provided to the CNSC for information.

For example, SOE implementation has been completed at OPG for all "SOE systems". The SOE documentation has been completed and formally issued. Gaps between SOE requirements and operating documentation have been identified; safety-significant compliance gaps that could adversely impact the conclusions of the safety analysis report and supporting analyses have been resolved. All remaining gaps have been dispositioned using OPG's change control processes, with resolution prioritized in a time frame commensurate with safety significance.

With SOE implemented, OPG has commenced the maintenance phase. OPG periodically reviews document changes resulting from changes in design, operation, safety analysis or licence requirements against the SOE documents and revises them on an as-needed basis.

Suggestion S7 from initial IRRS mission in 2009

"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 peer-review team for the follow-up IRRS mission in 2011 noted that the CNSC had developed a consistent approach in collaboration with the licensees. The CNSC has initiated a project that 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. The peer-review team closed suggestion S7 on the basis of progress and confidence that the remaining implementation steps would be undertaken.

The CSA standard *Requirements for the Safe Operating Envelope of Nuclear Power Plants* (N290.15) was issued in 2010 and outlines a consensus approach to defining, implementing and maintaining the SOE at operating NPPs. The standard is being added to the licences to operate NPPs as the licences are renewed. The CNSC conducted a pilot Type 1 inspection of the SOE at Pickering A in May 2011.

In 2011, a joint CNSC/industry working group was created to assess the implication of removing the operating limits and conditions from OP&P documents, instead including them in the LCHs for NPPs.

Design differences among the CANDU NPPs in Canada, along with the fact that their SOE programs have been initiated at different times, have given rise to variations among the NPPs in terms of the systems that are explicitly identified for inclusion in the SOE scope. The SOE working group report summarized the criteria for defining the minimum set of safety functions required to be included in the scope of SOE, based on CSA N290.15. To assist with the implementation of SOE programs complying with CSA N290.15, the report also identified the SOE systems for the operating NPPs, including explanations for the variations that exist among NPPs. Overall, there is strong alignment among the NPPs. Most of the variations are attributable to differences in plant design or safety analysis credits, or licensee preference in terms of how system boundaries are defined for SOE documentation purposes. A small number of additional variations arise in cases where licensees have, at their discretion, chosen to include or exclude additional systems based on their risk significance or other factors. All variations have been rationalized relative to application of the requirements and guidelines specified in CSA N290.15. The NPPs have also used different methods to document their SOEs, such as operational safety requirements or other basis documents.

All the NPP licensees are scheduled to complete the modification of critical limiting conditions by 2013.

19 (iii) Procedures for operation, maintenance, inspection and testing

Operation, maintenance, inspection and testing of systems, equipment and components at the NPPs are conducted in accordance with approved governance and procedures. The governance and procedures are incorporated into various licensee programs (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 for establishment and implementation of preventive, corrective and predictive maintenance; periodic inspections, tests, repairs and replacements; training of personnel; procurement of spare parts; provision of related facilities and services; and generation, collection and retention of operating and maintenance records. All NPP operating licences contain conditions that specify the requirements for these activities.

For example, the CNSC document *Maintenance Programs for Nuclear Power Plants* (S-210) is cited in all operating licences. S-210 sets the requirements for policies, processes and procedures that provide direction for maintaining the SSCs of each NPP. The range of maintenance activities specified includes monitoring, inspecting, testing, assessing, calibrating, servicing, overhauling, repairing and replacing parts. The purpose of these activities is to ensure that the reliability and effectiveness of all equipment and systems continue to meet the standard established in the licensing basis.

The CNSC document *Reliability Programs for Nuclear Power Plants* (S-98) is also cited in all NPP operating licences. 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, modelling, monitoring and other measures to assess the reliability of those systems
- include provisions to assure, verify and demonstrate that the program is implemented effectively
- document the elements of the program
- report the results of the program

The identification of systems important to safety is done using input from PSAs (see subsection 14(i)(d)), deterministic analyses (see subsection 14(i)(c)) and expert panels.

Operations are governed by the OP&P for each NPP, which, among other things, sets 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 percent). 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 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). Less significant issues are also reported for trending purposes.

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, testing and reliability. Improvements to surveillance hardware and software were also implemented, to improve component and system surveillance and trending capabilities. An improved gaseous fission product monitoring system has been installed at Darlington to help identify defective fuel for timely removal from the core. Improvements to fuel handling are also being implemented at Pickering and Darlington, which will improve the reliability of the fuel handling systems and improve reactivity management. Bruce Power improved the reliability of the standby generators by upgrading the control systems on two of the four generators at Bruce B during the reporting period. The remaining two standby generators will have their controls upgraded during the next reporting period along with the four standby generators at Bruce A.

19 (iv) Procedures for responding to operational occurrences and accidents

The *Class I Nuclear Facilities Regulations* require each NPP licensee to maintain onsite emergency plans and a response capability. Emergency plans and programs, including accident management provisions, are submitted to the CNSC as part of the licence application (see subsection 16.1(b) for details). The CNSC also observes emergency drills and exercises to confirm adequate implementation of the licensees' onsite provisions in their emergency response plans.

It is recognized that the consequences of reactor accidents can be minimized by sound onsite and offsite accident management. This is achieved by developing operating procedures in advance to assist and guide operators in responding to accidents.

All Canadian NPPs have a comprehensive set of manuals and procedures – covering normal plant operation, minor upsets and accident conditions – that are routinely tested in onsite drills.

Procedures used by NPP staff during routine operation of the NPP and its auxiliary systems are located in the operating manuals. The operating manuals contain:

- system-based procedures that assist the operators during normal operations, such as system start-up and shutdown and minor malfunctions limited to individual systems
- overall unit-control procedures that coordinate major evolutions such as unit start-up and shutdown and major plant transients
- alarm response manual procedures that provide the operations staff with information regarding alarm functions; typical information provided includes set points, probable causes of alarms, pertinent information, references and operator responses

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 among NPPs, the system generally contains:

- an abnormal incident manual
- a special safety system impairments manual (which may be a subset of the abnormal incident manual)
- a radiation protection manual (or radiation protection directives)

The suite of abnormal incident manual procedures directs the operations staff following safety system impairment, process system failure or a common mode event. These are typically event-based procedures and have as their end points the safe shutdown of the unit. Critical safety parameter procedures provide support for all procedures but are especially useful during transients. Critical safety parameter procedures provide structure for the augmented monitoring of critical NPP operating parameters during specific accident conditions and in cases when the specific event cannot be determined. They provide symptom-based frameworks for controlling the reactor, cooling the fuel, and containing radioactivity.

Radiation protection manual procedures are provided to protect the safety of the operators and the general public under normal conditions and in the event of a significant radiation incident. These procedures:

- direct event classification and categorization
- make provisions for offsite notification
- direct protective actions and monitoring during accident conditions

A condition in the existing licences to operate NPPs requires each licensee to maintain the minimum staff complement to make sure that there are always sufficient numbers of appropriately qualified staff available to respond to emergencies (for details, see annex 11.2(a)).

The fundamental elements of licensee procedures for responding to anticipated operational occurrences and events were unchanged during the reporting period. In general and as described in previous reports, licensees developed, and continue to maintain, operating procedures for dealing with anticipated operational occurrences, situations and events. Events are typically followed up by formal determination of root causes with corrective actions that are commensurate with the situation.

Examples of safety-significant operational events occurring at Canadian NPPs during the reporting period are listed in appendix 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 deficiencies and in 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.

As stated in subsection 14(i)(a), the CNSC Fukushima Task Force confirmed that operating procedures and equipment are in place in all NPPs to ensure that the key safety functions are carried out for extended durations and to bring the reactor to a safe, stable state following an accident.

Severe accident management

Severe accident management (SAM) focuses on preventing the progression of a beyond-design-basis accident into a severe accident or mitigating a severe accident when the preventive means have failed. SAM relies on the development of guidance and procedures for use by NPP staff. SAM can be enhanced by bringing in external resources to supplement or replace the onsite resources; these may include fuel, water, electric power or equipment such as pumps or generators. The CNSC's expectations for SAM are given in the CNSC guidance document *Severe Accident Management Programs for Nuclear Reactors* (G-306), published in 2006.

The measures to be implemented differ somewhat, depending on the location and nature of the NPP, as some NPPs are single-unit facilities in relatively remote rural locations and others are multi-unit facilities close to major urban centres. Offsite emergency response measures (described in subsection 16.1(d)), which are the responsibility of the provincial government in which the NPP is located, 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 test the full scope of provincial plans.

In support of SAM and accident management in general, the CNSC identified a need to more explicitly define the regulatory requirements for accident management. As a consequence of the CNSC Action Plan, the Task Force assigned an action to the CNSC to fully review and consider potential changes to G-306, in order to reflect lessons learned from Fukushima on SAM and to develop a dedicated regulatory document on accident management. Work on the revision of G-306 is in progress. The CNSC is also developing a regulatory document on accident management programs for nuclear reactors. CNSC staff are closely monitoring international developments in this area – any additional guidance identified in the IAEA project that is related to this subject will be incorporated into this document.

The CNSC Action Plan also assigned an action to the CNSC to add a condition to the operating licences of the NPPs requiring the development and implementation of operational guidance and adequate capabilities to deal with abnormal situations, emergencies and accidents (including severe accidents) and, where applicable, multi-unit events. The proposed licence condition was included in the licence to operate Darlington when it was renewed in March 2013. The condition will be added to other licences either upon renewal or as part of an amendment during the next reporting period.

Following the Fukushima event, CNSC staff reviewed the licensees' assessments of severe accidents (see subsections 14(i)(a), (c), and (d)) and their provisions for using existing plant capabilities, complementary design features and emergency mitigating equipment in SAM and recovery. CNSC staff have confirmed that adequate provisions for SAM and recovery are in place.

Examples of design changes that have been made at the NPPs to address conditions that could occur during severe accidents are described in annex 18(i) (specific to Point Lepreau and Bruce A). The CNSC Action Plan recommended a number of enhancements to mitigating capabilities, which are currently being pursued by licensees (described in subsection 16.1(b)). The licensees are expanding, or have already expanded, their SAM programs to utilize these additional resources. Multi-unit events and the assurance of irradiated fuel bay cooling and water inventory during reactor-based events are being addressed. The licensees have identified options for utilizing emergency mitigating equipment to prevent a severe accident. Some of this work is already completed and emergency mitigating equipment is in place.

The NPP licensees and AECL are participating in a COG joint project, "CANDU Severe Accident Support to Industry – Post Fukushima". Its purpose is to allow COG members to work in collaboration to align SAM assessments and methodology for implementing actions and developing plans in response to Fukushima.

Severe accident management guidelines

Challenge C-3 for Canada from the Fifth Review Meeting
"Complete implementation of Severe Accident Management Guidelines (SAMGs)"

The response of NPP operations to a severe accident would be to declare a general emergency at the NPP and activate the onsite emergency response. Changes to facilitate SAM 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.

Severe accident management guidelines (SAMGs) have been developed in recent years to guide onsite responses to severe accidents. SAMGs make use of complementary design features, such as PARs, emergency containment filtered vent systems, and calandria vault makeup, which are discussed in subsection 18(i), and mitigating measures, which are discussed in subsection 16.1(b). SAMG development has included the development of procedural guidance for the operating staff and technical support groups, specific training and appropriate drills.

SAMGs were developed by building both on the existing structure of emergency operating procedures and on international experience and guidance adapted to the CANDU design and expected severe accident progression. A symptom-based approach was used to allow NPP personnel to identify suitable actions to bring the NPP to a stable and controlled state. As an initial step, SAMG development focused on developing guidelines that start at the at-power state. These include:

- site-specific severe accident guides to protect fuel cooling
- severe challenge guides to
  - protect containment structural integrity
  - address irradiated fuel bay conditions during reactor-based events
  - minimize consequential releases utilizing existing engineered mitigating systems

The implementation of SAMGs is in various stages of completion at the NPPs. They have been largely implemented at all NPPs except at Gentilly-2, where Hydro-Québec is developing a specific program for the irradiated fuel bay while the NPP proceeds towards decommissioning.

In response to Fukushima, NPP licensees reviewed their procedural guidance and design capabilities of operating NPPs to cope with accidents, including those involving significant core damage. CNSC staff found that the licensees' SAMGs are generally adequate. Following Fukushima, the CNSC assigned a three-part action to licensees related to SAMGs:

- develop/finalize and fully implement SAMGs at each NPP
- expand the scope of SAMGs to include multi-unit and irradiated fuel bay events (see the Canadian report for the Second Extraordinary Meeting of the CNS for details)
- validate and/or refine SAMGs to demonstrate their adequacy to address lessons learned from Fukushima

Some licensees have completed the implementation and validation of SAMGs. The licensees have also developed plans to address the necessary enhancements (multi-units and irradiated fuel bays) – this work is being facilitated by a COG joint project. The licensees are also increasing the focus on severe accidents triggered by extreme events.

As part of the overall strategy and requirements for implementation of SAMGs, licensees have developed, or are developing, enhanced training programs to clarify roles and familiarize staff with the procedures and test their effectiveness.

Validation of the documentation and training is being done through validation drills, with much validation already complete. Once validated, SAMGs are incorporated into the existing emergency plans and the additional roles are incorporated into the existing response organizations. At that point, SAMGs are exercised in the regular emergency drill and exercise program. The CNSC is monitoring the rollout of SAMGs at each NPP and observing some of the validation exercises.

Further details on the development and implementation of SAMGs at each NPP during the reporting period are provided in annex 19(iv).

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 that include research, engineering, analysis, assessment, maintenance, inspections and design support. The CANDU R&D program, which supports the operating NPPs, is described in appendix 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 positions, and how the results received will be managed.

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 that might affect safety:

- sufficient staff to maintain specialized expertise in the required discipline (e.g., thermal hydraulics)
- in-depth knowledge of past and present regulatory issues
- rapport with regulatory staff specialists
- in-depth knowledge of NPP design and operation
- ongoing, positive relationships with internal stakeholders
- excellent written and oral communication skills
- ability to provide leadership on technical issues within the Canadian nuclear industry

The NPP licensees utilize a design authority function to ensure that the integrity of approved designs and the design process is maintained. The design authority is executed by the chief engineer. 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 ensures that:

- a knowledge base of relevant aspects of the facility and products is established and kept up to date, while experience and research findings are taken into account
- all design information required for a safe facility is available
- the requisite security measures are in place
- design configuration is maintained for approved designs
- appropriate design verification is applied
- all necessary interfaces are in place
- all engineering and scientific skills are maintained
- appropriate design rules and procedures, including codes and standards, are used
- engineering work is executed by qualified staff using appropriate methods in compliance with procedures

19 (vi) Reporting incidents significant to safety

Licensees use station condition records or event reports to provide information on undesirable events that are considered significant in the operation of NPPs. The licensees determine the significance of these events using specific operational procedures. During the reporting period, the licensees reported safety-significant events to the CNSC in a timely manner and in accordance with the requirements of the CNSC document *Reporting Requirements for Operating Nuclear Power Plants* (S-99), which is cited in the existing licences to operate NPPs. Additional information on the requirements and the work of CNSC staff to track and follow up on safety-significant events at NPPs is provided in subsection 7.2(iii)(b).

The CNSC rates specific events per the International Nuclear Event Scale (INES). During the reporting period, all events rated using the INES scale were evaluated to be level 1 or below-scale (i.e., level 0). The CNSC also submits the descriptions of certain reports to the IAEA Nuclear Event Web-based System (NEWS) to ensure that the safety significance of events is promptly understood at the international level. The CNSC posted one below-scale (i.e., level 0) event on the NEWS Web site during the reporting period for public interest purposes.

Canada is also committed to reporting to the International Reporting System, operated by both the IAEA and the NEA, on significant events occurring in Canadian NPPs. Canada appointed a member of the CNSC staff as a national coordinator to collect, analyze and submit information on events occurring in Canada. Actions taken in Canada to address events reported internationally are presented annually by Canada through its delegates to the appropriate fora, such as the International Reporting System technical committee and/or 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 event initial reports, which are submitted to the Commission members. Guidance for screening was developed during the reporting period and is currently being revised.

At all NPPs, 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 (WANO) peer reviews, design weaknesses) is rated using criteria in the corrective action program.

19 (vii) Operational experience feedback

The NPP licensees conduct analysis and trending of events with relatively small safety significance, in order to help prevent the occurrence of events with more significant consequences. The licensees have active OPEX programs facilitated by COG, WANO and EPRI. A description of the programs to collect and analyze information on OPEX is provided in annex 19(vii).

At the CNSC, information obtained from the IAEA International Reporting System and the NEA Working Group on Operating Experience, as well as other sources, is systematically disseminated. 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 incorporate results of root-cause analyses in their reviews and assessments of a licensee's corrective actions in response to a certain event. Further actions are requested if the corrective actions undertaken by the licensee are considered inadequate. In addition, the CNSC site inspectors review the status of corrective actions to make sure that they have been completed expeditiously.

CNSC inspection teams consult the OPEX 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 utilize the OPEX recorded in this database. As part of the inspection baseline, CNSC inspectors check the licensee's station condition records or event reports, along with system health reports, to ensure that OPEX and the extent of condition have been applied to the systems by the licensees.

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 waste. Primary responsibility for the storage and long-term management of radioactive waste and spent fuel rests with waste producers and owners (licensees).

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Operations

Canadian NPPs manage radioactive waste using methods similar to those practised 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 the 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:

- 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.

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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:

- 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 and spent fuel management

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.

The NPP licensees have instituted methods to recover storage space after sufficient radioactive decay or reclaim existing storage space through further compaction (super compaction) and/or segregation.

It is possible to retrieve all stored radioactive waste.

All spent fuel from NPPs is stored in interim storage at the site where it was produced. When the fuel first exits the reactor, it is placed in water-filled irradiated fuel bays for cooling and radiation shielding. After several years in the bays – six to ten years, depending on site-specific needs and administrative controls – and when the associated heat generation has diminished, the spent fuel is transferred to an onsite, interim dry storage facility.

As for all nuclear activities, the facilities for handling radioactive waste and spent fuel 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 NPPs – is the same, which is to control and limit the release of potentially harmful substances into the environment. CNSC staff inspect all licensed facilities to confirm the achievement of these objectives.

Further information on Canada's provisions for radioactive waste and spent fuel can be found in the *Fourth 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 2011. This report is available on the CNSC and IAEA Web sites.

APPENDICES

Appendix A
Relevant Web Sites

Document or organization	Web site
Nuclear Safety and Control Act	http://laws-lois.justice.gc.ca/eng/acts/N-28.3/index.html
Canadian Environmental Assessment Act	http://laws-lois.justice.gc.ca/eng/acts/C-15.21/index.html
General Nuclear Safety and Control Regulations	http://laws-lois.justice.gc.ca/eng/regulations/SOR-2000-202/page-1.html#ord
Class I Nuclear Facilities Regulations	http://laws-lois.justice.gc.ca/eng/regulations/SOR-2000-204/index.html
Radiation Protection Regulations	http://laws-lois.justice.gc.ca/eng/regulations/SOR-2000-203/index.html
Canadian Nuclear Safety Commission Cost Recovery Fees Regulations	http://laws-lois.justice.gc.ca/eng/regulations/sor-2003-212/page-1.html
Atomic Energy of Canada Limited (AECL)	http://www.aecl.ca
Bruce Power Inc.	http://www.brucepower.com
Canadian Nuclear Safety Commission (CNSC)	http://www.nuclearsafety.gc.ca
Canadian Environmental Assessment Agency	http://www.ceaa-acee.gc.ca
Candu Energy Inc.	http://www.candu.com
CANDU Owners Group (COG)	http://www.candu.org
CANTEACH	http://canteach.candu.org
Health Canada (HC)	http://www.hc-sc.gc.ca
Hydro-Québec	http://www.hydroquebec.com
International Atomic Energy Agency (IAEA)	http://www.iaea.org
Natural Resources Canada (NRCan)	http://www.nrcan.gc.ca/
New Brunswick Power Nuclear (NBPN)	http://www.nbpower.com/
Ontario Power Generation (OPG)	http://www.opg.com
University Network of Excellence in Nuclear Engineering (UNENE)	http://www.unene.ca
University of Ontario Institute of Technology (UOIT)	http://www.uoit.ca/

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	Refurbished (Commercial Operation Oct. 22, 2012)
Bruce A, Unit 2	Bruce Power	904	Dec. 1, 1970	Jul. 27, 1976	Refurbished (Commercial Operation Oct. 31, 2012)
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	Shut down – Defuelling in progress
Pickering A, Unit 1	OPG	542	Jun. 1, 1966	Feb. 25, 1971	Operating
Pickering A, Unit 2	OPG	542	Sep. 1, 1966	Sep. 15, 1971	Safe Storage State
Pickering A, Unit 3	OPG	542	Dec. 1, 1967	Apr. 24, 1972	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	705 (post-refurbish-ment)	May 1, 1975	Jul. 25, 1982	Refurbished (Commercial operation Nov. 23, 2012)

Appendix C
Examples of Descriptions and Plans Required to Support an Application to Renew a Nuclear Power Plant Operating Licence

Summary of programs organized by safety and control areas (not limited to the listed topics)		
1. Management system • Nuclear management system / nuclear safety policy • Managed systems / records and document control • Business planning / nuclear organization / organizational change control / contractor management program • Nuclear safety oversight / independent assessment / nuclear safety culture assessment	**2. Human performance management** • Human performance / technical procedures • Continuous behaviour observation program / limits of hours of work / minimum shift complement • Leadership and management training / training	**3. Operating performance** • Nuclear operations / OP&Ps • Safe operating envelope / operational safety requirements • Plant status control / chemistry • Operating experience process / corrective action • Reactor safety program / reactivity management / heat sink management / response to transient
4. Safety analysis • Reactor safety program / risk and reliability program • Safety report (all parts) / analyses of record	**5. Physical design** • Conduct of engineering / engineering change control / procurement engineering • Design management / configuration management • Fuel • Pressure boundary program • Environmental qualification • Software	**6. Fitness for service** • Conduct of maintenance / integrated aging management • Equipment reliability / component and equipment surveillance / reliability and monitoring of systems important to safety • Major component / lifecycle management plans • Non-destructive examination
7. Radiation protection • Radiation protection / controlling exposure ALARA • Occupational action levels	**8. Conventional health and safety** • Health and safety policy • Conventional safety / work protection	**9. Environmental protection** • Environmental policy / environmental management / derived release limits and environmental action levels
10. Emergency management and fire protection • Emergency management policy / nuclear pandemic plan / consolidated nuclear emergency plan • Fire protection	**11. Waste management** • Nuclear waste management program • Waste management • Decommissioning planning / preliminary decommissioning plan	**12. Security** • Nuclear security • Security report
13. Safeguards and non-proliferation • Nuclear safeguards	**14. Packaging and transport** • Radioactive material transportation	**Other matters of regulatory interest** • Financial guarantees / nuclear liability insurance • Public information program • Aboriginal consultation

Appendix D
Significant Events During Reporting Period[6]

Location/date	Description	Corrective action by licensee	Regulatory action
Bruce A January 23, 2012 Tritium alarm in the auxiliary services building	A tanker truck, used exclusively for heavy-water transport on the controlled NPP site, was carrying heavy water from Bruce B to the Bruce A auxiliary services building for storage, where it alarmed the tritium detectors. Personnel in the Bruce A auxiliary services building were evacuated immediately upon the sounding of the tritium alarms. Surveys were performed and an exclusion boundary was established to prevent unplanned exposures.	As a precautionary measure, site security immediately closed the roads that the truck had travelled. Shortly thereafter, the roads were confirmed to be clear and were reopened (soil samples were taken along the route with no indication of leakage detected). Bruce Power verified that there was no measurable loss of heavy water. The Bruce A "Fix It Now Team" replaced and quarantined the rupture disk for the tanker and sent it for forensic examination. The rupture disk on a similar tanker at Bruce B was inspected and pressure-tested in accordance with procedures. Bruce Power stopped heavy-water shipments until the root-cause investigation was completed. Bruce Power management reviewed and rolled out a job safety analysis/task risk analysis for heavy-water tanker moves with all Transportation Services personnel. The Operations Programs department updated the heavy-water management program to define roles, responsibilities, expectations and interfaces for onsite heavy-water shipments. Areas	CNSC staff performed a preliminary investigation of the event to assess the adequacy of Bruce Power's response and to ensure that no consequential risk was posed to workers and the environment.

[6] All the events listed in this appendix were presented to the Commission during public hearings/meetings. Note that the last entry in the table did not involve an NPP. Although out of scope for this report, the description of the event at Chalk River Laboratories is included because it was one of the more significant events during the reporting period in Canada.

Location/date	Description	Corrective action by licensee	Regulatory action
		addressed included container evaluation, security escorts, route planning, equipment lifecycle management, preventive maintenance and training. Finally, as a result of further analysis, Bruce Power decided to change shipment methods from the previously used tankers to purpose-designed flasks.	
Darlington Unit 3 July 28, 2011 Manual trip of shutdown system 1	During routine maintenance on a shutoff rod while Unit 3 was operating at full power, the odd bank (one of two sets) of rods fell into the reactor core. Shutdown system 1 was then tripped manually, according to procedure, and the unit was placed in a low-power hot state. This event was caused by the incorrect installation of two wires on the power supply to the clutch of the shutoff rod, which led to a short when a jumper was applied before the clutch control card was replaced. This released the clutches of the odd bank of rods, causing them to fall into the core. The fault had not been detected previously because the particular clutch control card had not been replaced with the unit at power.	The wires were restored to their intended locations, the wiring of the clutch control cards for the other shutoff rods was verified and the unit was returned to operation. The wiring for shutoff rods on other units was also verified. OPG modified its maintenance procedures to check voltages prior to installing jumpers on clutch control card circuits. OPG also reviewed OPEX to determine if similar occurrences happened in the past.	CNSC staff verified that the cause was understood and that the unit was safely restored to operation.
Pickering A Unit 4 February 24, 2011	A spill of moderator water inside the reactor building occurred, following a unit shutdown to investigate increased leakage of moderator water to collection. It had	The moderator pump was repaired and returned to service. OPG inspected the remaining moderator pumps on Unit 1 and Unit 4 for improperly installed couplings. Three pumps were found to	CNSC site staff monitored the repair and the root-cause investigation of the

Location/date	Description	Corrective action by licensee	Regulatory action
Moderator spill	been observed that the leakage rate from a moderator pump to the collection system had increased substantially. OPG decided conservatively to shut down the unit to investigate. Following shutdown, there was an indication of water in the moderator pump room sump, which itself indicated that moderator water was spilling onto the floor. Following extensive preparation, OPG staff entered the moderator pump room and isolated the leak. The team observed that the pump shaft had failed and the pump bearings and impeller seals were damaged considerably. The spill was contained entirely within the reactor building. There were no unplanned dose to workers. Because of the spill, the breakers to three of the pumps were opened to prevent any problems should the pumps be exposed to water. This impaired the emergency core cooling system because, in the Pickering A design, these moderator pumps are used to recirculate the injected water. The impairment was reported to CNSC staff as required but was cleared shortly afterwards when the primary heat transport system was cooled below 90ºC.	have gaps in the couplings that exceeded the allowable tolerance. The couplings on these pumps were removed, cleaned and reinstalled to eliminate the gaps. Run-out tests and vibration readings were performed and the results were acceptable. OPG investigated the causes of the failure, and both Pickering A and Pickering B conducted follow-up. Pickering B engineering staff reviewed coupling installation and mechanical maintenance procedures for deficiencies. Pickering A maintenance staff conducted a departmental self-assessment to identify gaps in worker knowledge and address them by updating training material. OPG revised its *Requirement for Technical Procedures* so that the identified procedural weaknesses were captured in all procedure revisions. OPG also developed a case study detailing the failure of the pump and presented it to all Pickering A maintenance staff.	failure.
Chalk River Laboratories	An earthquake of magnitude 5 occurred 60 km north of Ottawa and was felt at the	Some facilities and buildings were evacuated immediately following the earthquake. The	The CNSC contacted the licensee and CNSC site

Location/date	Description	Corrective action by licensee	Regulatory action
June 23, 2010 Earthquake	Chalk River Laboratories.	earthquake was not strong enough to reach the set points of the seismic trip of the NRU second trip system. The nuclear facilities and other buildings were subsequently walked down/visually inspected to confirm that no significant damage had occurred. There were no injuries. AECL made a verbal report and submitted an S-99 report to the CNSC.	office to ensure that staff were safe and appropriate actions were taken. CNSC staff posted an information notice on the IAEA Nuclear Event Web-based System (NEWS).

Appendix E
Nuclear Safety Research in Canada Related to Nuclear Power Plants

E.1 Introduction and context

Canada holds the view that nuclear safety research is important in supporting safe NPP design and operation. In Canada, it is the responsibility of the applicant, with the aid of the NPP 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 subsection 14 (i)). This risk-informed position is of particular importance in focusing research efforts on safety-significant areas and facilitating 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
- 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. COG also arranges other projects that are executed by EPRI and other R&D contractors and which contribute another $15–$20 million annually to R&D that supports NPPs in Canada.

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: addresses licensing concerns (GAI closure) and restoration of operating and safety margins associated with predicted power pulses postulated for LBLOCA events (see LBLOCA 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: addresses 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 uranium dioxide 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: addresses 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
- Consolidates the qualification, development and maintenance of different computer codes used for the design, safety analysis and operational support of CANDU reactors (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 (see section D.1 of chapter I for more information). Much of AECL's R&D is conducted through the COG R&D program described in subsection E.2. 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 programs listed below.

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 the organization’s 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.

Contracts issued under the research and support program align with the CNSC's research-related safety and control areas, which address the following CNSC activities:

- Consolidating data and performance research to determine health, safety and environmental benchmarks ranging from release limits of substances to any emerging new concerns
- Determining licensing requirements for new reactors and uranium mines
- Identifying licensing issues and determining regulatory position given the age of the Canadian nuclear fleet
- 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 up-to-date knowledge for use in regulatory functions

The research and support program issues grants and contributions to organizations and initiatives, such as the following:

- University Network of Excellence in Nuclear Engineering (UNENE)
- International Atomic Energy Agency (IAEA)
- International Commission on Radiation Protection (ICRP)
- CSA Group
- Multinational Design Evaluation Programme (MDEP)
- OECD Component Operational Experience, Degradation and Ageing Programme (CODAP)
- Deep River Science Academy

The annual budget of the Research and Support Program is approximately $3 million. On average, the program manages between 60 and 80 projects each year, with many projects running over more than one fiscal year.

E.5 Generation IV International Forum

Canada is a founding member of the Generation IV International Forum, which was initiated in 2001 to collaboratively develop the next generation of nuclear energy systems that will provide safe and reliable energy in a competitively priced and sustainable way.

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

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

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

As part of Canada's overall national program, research funds are granted to universities through a peer-review process to investigate specific areas that support the development of the supercritical water-cooled reactor concept. In March 2012, the Government of Canada awarded grants that will provide $8 million over four years to fund 27 Generation IV research projects at universities across Canada.

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 and control areas consists of five categories:

FS	Fully Satisfactory
SA	Satisfactory
BE	Below Expectations
UA	Unacceptable

The full definitions of the new categories 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.

Table F.1 provides the definitions of the 14 CNSC safety and control areas that were used during the reporting period. These replace the older set of safety areas and programs that were described in previous Canadian reports and are now used for all facilities licensed by the CNSC. All the ratings discussed in this report are for this set of safety and control areas.

Table F.1: CNSC functional areas, safety and control areas, and specific areas used in rating Canadian NPP performance

Functional area	Safety and control area	Specific area
Management	Management system	Management system
		Organization
		Change management
		Management performance
		Safety culture
		Configuration management
		Business continuity
	Human performance management	Human performance program
		Personnel training
		Personnel certification
		Initial certification examinations and requalification tests
		Work organization and job design
		Procedures and job aids
		Fitness for duty
	Operating performance	Conduct of licensed activities
		Procedures
		Operating experience
		Reporting and trending
		Outage management performance
		Safe operating envelope
		Accident management and recovery
		Severe accident management and recovery
Facility and equipment	Safety analysis	Deterministic safety analysis
		Probabilistic safety assessment
		Criticality safety
		Severe accident analysis
		Environmental risk assessment
		Management of safety issues (including R&D programs)
	Physical design	Component design
		Equipment qualification
		System design and classification
		Human factors in design
		Robustness design
		Engineering change control
		Site characterization
	Fitness for service	Equipment fitness for service / equipment performance
		Maintenance

Functional area	Safety and control area	Specific area
		Structures, systems and components (SSCs) monitoring
		Reliability of systems important to safety
		Pressure boundary integrity
		Aging management / lifecycle management
		Periodic inspections of pressure boundary components and containment structures
		In-service inspections for balance-of-plant
Core control processes	Radiation protection	Application of ALARA
		Worker dose control
		Personnel dosimetry
		Contamination control
		Estimated dose to public
	Conventional health and safety	Compliance with labour code
		Housekeeping / management of hazards
		Accident severity and frequency
	Environmental protection	Effluent and emissions control (releases)
		Environmental management system
		Environmental monitoring
	Emergency management and fire protection	Conventional emergency preparedness and response
		Nuclear emergency preparedness and response
		Fire emergency preparedness and response
	Waste management	Waste minimization, segregation and characterization
		Waste storage and processing
		Decommissioning plans
	Security	Facilities and equipment
		Access control
		Training, exercises and drills
		Nuclear response force
	Safeguards and non-proliferation	Nuclear material accountancy and control
		Access and assistance to the IAEA
		Operational and design information
		Safeguards equipment, containment and surveillance
		Import and export
	Packaging and transport	Packaging and transport

IAEA safety factors are from IAEA specific safety guide No. SSG-25 *Periodic safety Review for Nuclear Power Plants*

Table F.2: Comparison of IAEA safety factors to CNSC safety and control areas

IAEA safety factor	Related CNSC safety and control areas
Plant design	Management system, operating performance, safety analysis, physical design, fitness for service, radiation protection, conventional health and safety, environmental protection,
Actual condition of systems, structures and components	Management system, safety analysis, physical design, fitness for service, radiation protection, conventional health and safety, environmental protection
Equipment qualification	Management system, safety analysis, physical design, fitness for service, radiation protection, conventional health and safety, environmental protection
Ageing	Management system, human performance management, operating performance, safety analysis, physical design, fitness for service, radiation protection, conventional health and safety, environmental performance
Deterministic safety analysis	Management system, safety analysis, physical design, fitness for service, radiation protection, emergency management and fire protection
Probabilistic safety assessment	Safety analysis, physical design, fitness for service
Hazard analysis	Management system, operating performance, safety analysis, physical design, fitness for service, radiation protection, conventional health and safety, environmental protection, emergency management and fire protection, security, safeguards and non-proliferation, transport and packaging
Safety performance	Management system, operating performance, safety analysis, fitness for service, radiation protection, conventional health and safety, environmental protection, waste management
Use of experience from other plants and research findings	Management system, human performance management, operating performance
Organization, management system and safety culture	Management system, human performance management, operating performance
Procedures	Management system, human performance management, operating performance, radiation protection, conventional health and safety, emergency management and fire protection
Human factors	Management system, human performance management, operating performance, fitness for service, radiation protection, conventional health and safety

IAEA safety factor	Related CNSC safety and control areas
Emergency planning	Management system, human performance management, operating performance, conventional health and safety, emergency management and fire protection
Radiological impact on the environment	Management system, operating performance, environmental protection

Table F.3: Performance ratings of safety and control areas for NPPs for the years 2010, 2011 and 2012

	Bruce A			Bruce B			Darlington			Pickering A			Pickering B			Gentilly-2			Point Lepreau		
	’10	’11	’12	’10	’11	’12	’10	’11	’12	’10	’11	’12	’10	’11	’12	’10	’11	’12	’10	’11	’12
Management system	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Operating performance	SA	SA	SA	SA	SA	SA	FS	FS	FS	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Safety analysis	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Physical design	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Fitness for service	SA	SA	SA	SA	SA	SA	FS	FS	FS	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Radiation protection	BE	SA	SA	SA	SA	SA	FS	FS	FS	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Conventional health and safety	FS	FS	FS	FS	FS	FS	FS	FS	FS	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	FS
Environmental protection	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Emergency management and fire protection	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	BE	SA	SA
Waste management	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Integrated plant rating	SA	SA	SA	SA	SA	SA	FS	FS	FS	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA

Legend:
Categories for 2010, 2011, 2012 Ratings FS = Fully satisfactory SA = Satisfactory BE = Below Expectations

Note: The grades for the CNSC safety and control areas “site security” and “safeguards and non-proliferation” 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 by 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 the previously existing generic action items (GAI) were included in the list that was considered. GAIs were regulatory tools that had been used to define the scope of certain safety issues that are common to more than one NPP and track the progress of their resolution. GAIs have been phased out as a regulatory tool - the remaining GAIs were closed during the reporting period (see table G.1).

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 means issues that have been satisfactorily addressed in Canada
- Category 2 identifies issues that are a concern in Canada, but have appropriate measures in place to maintain safety margins
- Category 3 issues are a concern in Canada and measures are in place to maintain safety margins, but the adequacy of these measures needs to be confirmed

The existence of Category 3 issues should not be viewed as bringing into question the safety of existing NPPs, which have attained a very high operational safety record in Canada, but rather as the clear identification of 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 in order to identify, estimate and evaluate the risks associated with each of them and to recommend measures to control these risks. 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. The application of the RIDM process by a joint CNSC and 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 issues and addressing 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 4 of these issues to lower categories. The remaining 16 Category 3 issues include 6 associated with large-break loss-of-coolant accidents (LBLOCA) and 10 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 and fast-acting automated shutdown systems that are independent of the reactor control system. The two shutdown systems are complemented by robust emergency core cooling (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. An LBLOCA is the DBA used to set the requirements for the speed of the shutdown systems and the requirements for the ECC. An 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 the 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 be beyond-design basis accidents, they are currently treated as DBA in the Canadian regulatory framework.

The impact of a power pulse following a LBLOCA is explicitly analyzed in the safety analysis reports. The current safety analysis methodology used for LBLOCA scenarios incorporates numerous conservative assumptions with regard to the state of the 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 are being re-evaluated to confirm safe operation in light of experimental findings over the past decade, which concluded that the actual value of full-core void reactivity was higher than what was assumed in the safety analysis reports.

Four Category 3 CANDU safety issues that were open at the beginning of the reporting period are directly related to the reductions in the LBLOCA safety margins:

- analysis for void reactivity
- channel voiding during LBLOCA
- fuel behaviour in high temperature transients
- fuel behaviour in power pulse transients

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 margins 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 (backup 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 by improving the effectiveness of the shutdown systems or by 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

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 resolve analysis issues and assess failure probability and break-opening characteristics related to LBLOCA.

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 to define 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 increases with time
- 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.

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 all Bruce A and Bruce B units have been converted to fuelling with the flow. 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 percent 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 and ensure appropriate allocation of resources to this issue.

One of the Category 3 issues associated with LBLOCA – channel voiding during LBLOCA – was downgraded to Category 2 during the reporting period for all NPPs. The resolution of the remaining three LBLOCA-related, Category 3 CANDU safety issues is expected by the end of 2013.

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. Risk control measures have been identified for each issue and there is general 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. The industry has since completed all the activities recommended by the panel.

All risk control measures have been defined and plans to address them have been submitted to the CNSC. Much of the work required to address the issues has been completed, and requests for reclassification for all but one have been submitted to the CNSC. A number of issues have since been reclassified by the CNSC for some NPPs. During the reporting period, the non-LBLOCA Category 3 issue dealing with hydrogen control measures during accidents was downgraded to Category 2 for all NPPs. In the next reporting period, the other working groups will continue the work of addressing the remaining 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

The GAIs (defined above, under subsection G.1) that remained open at the beginning of the reporting period are now closed, as detailed in the table below.

Table G.1: Status of GAIs as of March 31, 2013

GAI	Title	Brief description	Date Closed
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.	2011
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.	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.	2012
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.	2010
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.	2012
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.	2012
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 increased 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.	2012

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 decisions are being made
- 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 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 predetermined courses of action.

The RIDM process integrates a spectrum of inputs to result in safe, sound and optimal decision making. These inputs include the following:

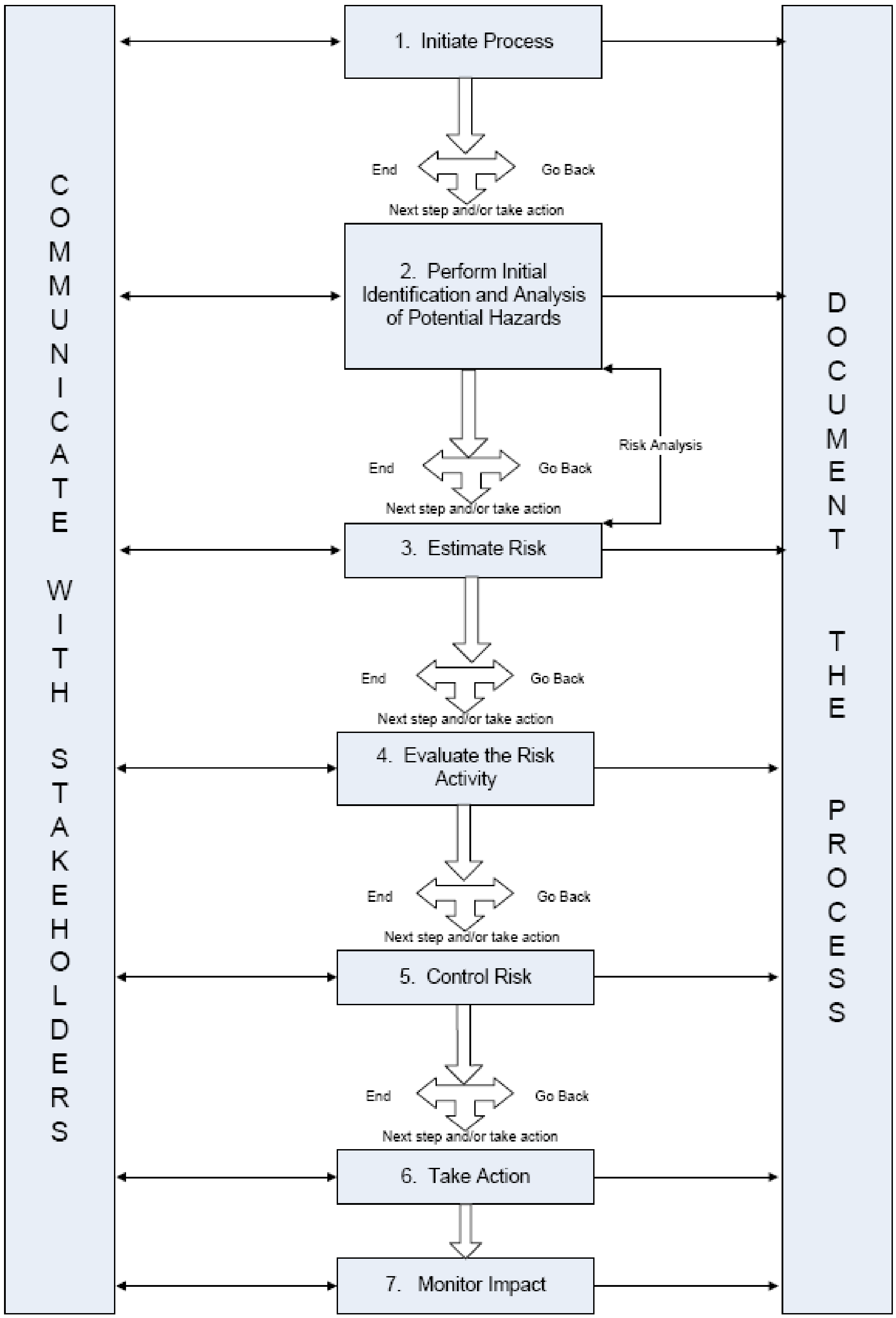
- regulatory requirements, standards and codes
- deterministic safety analyses
- probabilistic safety analyses
- risk impact
- operating experience
- other considerations (e.g., cost-benefit, socio-economic implications, legal aspects)

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).

Figure H.1: RIDM process



Example of the application of RIDM: Battery replacement

In 2010, OPG proposed to place Class 1 power on single supply while replacing all cells in the Unit 8 batteries and selected cells in the Unit 6 and 7 batteries. The cells to be replaced were experiencing excessive sedimentation, which the manufacturer claimed was caused by a manufacturing defect. While there was no operability concern at the time, a failure could have occurred if the sedimentation continued to build up. However, OPG's OP&Ps specified that "Class 1 batteries shall be maintained in the fully charged condition except during test." Therefore, OPG requested a temporary deviation from the OP&Ps.

OPG identified that Class 1 power on single supply would result in a Level 3 impairment of ECC (total loss of redundancy impacting ECC) and that battery procurement did not align with the unit outages, so replacement was proposed to be done at power. The replacement would have been done within the battery shelf-life window, and Unit 8 was expected to be on single Class 1 supply for 28 days, Unit 6 for 14 days and Unit 7 for 7 days.

The issue at hand was whether OPG's proposed deviation from the OP&Ps would result in an acceptable increase in risk.

By applying RIDM, it was determined that allowing the replacement of the Class 1 battery would have resulted in scenarios that involved increases in risk ranging from no increase to significant increases that approach the upper limit of the tolerable range. Since these scenarios were determined by chance rather than choice, any of them was possible, although some had a much higher probability than others. Additionally, it was found that requiring the battery replacement to be carried out during an outage would result in no increased risk. This was the lowest risk option.

Based on the review, CNSC denied OPG's request to deviate from the OP&Ps.

Example of the application of RIDM: Reinstallation of shutdown system trips

Bruce Power used an RIDM process during the return to service of Bruce A Units 1 and 2 to conclude that there was insufficient benefit to reinstalling a shutdown system 1 (SDS1) trip on moderator header low pressure (MHLP) and a shutdown system 2 (SDS2) trip on moderator low flow (MLF), which had previously been removed from service. This process was developed by Bruce Power for use in integrated safety reviews and was in general alignment with the CNSC RIDM process.

In the risk evaluation, an integrated evaluation of the overall significance of the issue under consideration (i.e., the potential reinstatement of the MHLP and MLF trips) was undertaken, based on the risk calculation and factoring in of relevant deterministic considerations. A risk evaluation screen was used to provide guidance on the action necessary, and the benefit/cost ratios that should be applied to screen potential improvements, as a function of the risk significance. Risk significance was linked to the tolerability of that risk based on a risk tolerability scale similar to that used in the CNSC process.

The bounding values of incremental risk reduction associated with reinstating the trips were calculated to be:

- decrease in core damage frequency of 9.95×10^{-7}/yr for SDS1 MHLP
- decrease in core damage frequency of 4.61×10^{-7}/yr for SDS2 MLF

With the incremental risk reduction estimated to be below 10^{-6}/yr, the risk significance of **not** reinstating the trips was determined to be in the acceptable range and the risk evaluation screen indicated that the reinstatement of the trips would only be considered based on the ALARA principle and only where the implementation cost was less than $1 million per unit. Furthermore, the change would offer a significant improvement in the deterministic gap (i.e., adequacy of SDS trip coverage).

Based on the application of the RIDM screen, further action to reinstate the MHLP and MLF trips was determined to be unwarranted, based on the following:

- Risk assessment shows that the probability of severe core damage due to failure of shutdown action in moderator events is below 10^{-6}/yr and the overall risk significance of not making a change is in the "acceptable" range
- The estimated cost of implementation is disproportionately high relative to safety benefit (cost/benefit greater than 7.2 for SDS1 MHLP and greater than 14.8 for SDS2) and trip reinstatement is therefore not considered practicable
- From a deterministic perspective, the existing plant design provides significant defence in depth for moderator events, incorporating engineered and passive design features. The incremental deterministic safety benefit of partial additional backup trip coverage is considered to be of minor overall impact
- Based on a review of other factors (operational experience, operating impacts and regulatory considerations), there was considered to be no overriding intangible considerations that would cause the trip reinstatement option to be retained

After review of the Bruce Power assessment and RIDM document, CNSC accepted that the reinstatement of the trips was not necessary.

ANNEXES

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

When making or amending regulations, the CNSC must abide by the Government of Canada's regulatory policy *Cabinet Directive on Regulatory Management*, which came into effect in 2012. The Directive updates and replaces the *Cabinet Directive on Streamlining Regulation* (dated April 1, 2007) and the *Government of Canada Regulatory Policy* (dated November 1999).Under the *Cabinet Directive on Regulatory Management*, the CNSC works with the Regulatory Affairs Sector of the Treasury Board of Canada Secretariat 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
- overall expected impact (i.e., low, medium or high) and the particular analytical and other requirements to be met

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 for approval for prepublication in the *Canada Gazette*, Part I. Prepublication 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 from 30 to 75 days. Comments received during the prepublication period are posted on CNSC's Web site for interested parties to provide feedback.

Following the prepublication comment period, the draft regulations are amended, if necessary, to take into account the comments received from stakeholders. Once the final draft regulations are completed, they must again be circulated for internal approvals before being presented to the Commission. A regulation is "made" when it is officially established by the regulation-making authority. Under section 44 of the NSCA, the Commission may make regulations with the approval of the Governor in Council (Cabinet). Governor in Council approval is granted following a recommendation for approval from the Minister of NRCan. Once approved and registered, the new or amended regulations are published in the *Canada Gazette*, Part II.

Annex 7.2 (i) (b)
Regulatory Framework Documents

The information in this annex reflects the status of the CNSC regulatory document program at the end of the reporting period. As of April 2013, all regulatory documents are referred to as "REGDOC". The previous naming conventions are described in the footnote to table 1 below. REGDOCs may contain regulatory requirements (providing what licensees and applicants must achieve in order to meet the regulatory requirements of the CNSC), guidance (advising licensees and applicants on how to meet the regulatory requirements of the CNSC) or general information on CNSC practices and processes.

Regulatory documents are developed using a lifecycle approach, from identification of a regulatory issue or concern through analysis of the issue to determine the best regulatory tool to address the issues, development and publication of the document and finally to regular review and updating of the document. External stakeholders are provided the opportunity to comment on the proposed contents of individual documents through a rigorous public consultation process. This includes publication of the draft document on the CNSC's Web site and informing stakeholders of this through various vehicles, including email notifications, the CNSC Facebook page, the Government of Canada's Consulting with Canadians Web site. In addition, the CNSC makes use of newsletters or targeted mail-outs to ensure affected stakeholders are aware of the consultation. Stakeholders are invited to provide their comments through facsimile, email and conventional mail or through an online comment form. Following an initial consultation period, all comments received are published on the CNSC Web site, and feedback on these comments is invited from stakeholders.

The tables below list some key documents that are relevant to NPPs. CNSC documents are listed in table 1; they are available on the CNSC Web site at nuclearsafety.gc.ca. CSA documents are listed in table 2.

Table 1: CNSC regulatory framework documents related to NPPs

Doc # [7]	Document title	Status[8]
	Requirements for the Requalification Testing of Certified Shift Personnel at Canadian Nuclear Power Plants (2009)	x
EG-1	*Requirements and Guidelines for Written and Oral Certification Examinations for Shift Personnel at Nuclear Power Plants* (2005)	x
EG-2	*Requirements and Guidelines for Simulator-Based Certification Examinations for Shift Personnel at Nuclear Power Plants* (2004)	x
RD-204	*Certification of Persons Working at Nuclear Power Plants* (2008)	x
RD-310	*Safety Analysis for Nuclear Power Plants* (2008)	x
RD-321	*Criteria for Physical Protection Systems and Devices at High Security Sites* (2010)	x
RD-336	*Accounting an Reporting of Nuclear Material* (2010)	x
RD-337	*Design of New Nuclear Power Plants* (2008)	
RD-346	*Site Evaluation for New Nuclear Power Plants* (2008)	
RD-353	*Testing the Implementation of Emergency Measures* (2008)	x
RD-360	*Life Extension of Nuclear Power Plants* (2008)	x
RD-361	*Criteria for Explosive Substance Detection, X-Ray, Imaging and Metal Detection at High Security Sites* (2010)	x
RD-363	*Nuclear Security Officer Medical, Physical, and Psychological Fitness* (2008)	x
RD/GD 98	*Reliability Programs for Nuclear Power Plants* (2012)	x
RD/GD 99.3	*Public Information Disclosure* (2012)	x
RD/GD 210	*Maintenance Programs for Nuclear Power Plants* (2012)	
RD/GD-369	*Licence Application Guide: Licence to Construct a Nuclear Power Plant*	
GD-310	*Guidance on Deterministic Safety Analysis for Nuclear Power Plants* (2012)	
GD-336	*Guidance for Accounting and Reporting of Nuclear Material* (2010)	
REGDOC-2.2.2	*Personnel Training* (draft)	
REGDOC-2.2.3	*Personnel Certification: Radiation Safety Officers* (draft)	
REGDOC-2.12.2	*Site Access Security Clearance* (2012)	
P-119	*Policy on Human Factors* (2000)	

[7] The naming convention for regulatory documents has evolved over time. The AECB (predecessor to the CNSC) issued regulatory documents and also draft, consultative documents that were designated “C”. CNSC regulatory policies, standards, guides and notices were initially denoted by a “P”, “S”, “G” or “N,” respectively. Subsequently, the CNSC used the designation “RD” for documents containing requirements and “GD” for documents containing guidance. To facilitate the use of these documents, requirements and guidance were combined in RD/GD documents, now called simply REGDOCs.

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

Doc # [7]	Document title	Status[8]
P-211	*Compliance* (2001)	
P-223	*Protection of the Environment* (2001)	
P-242	*Considering Cost-Benefits Information* (2000)	
P-290	*Managing Radioactive Waste* (2004)	
P-299	*Regulatory Fundamentals* (2005)	
P-325	*Nuclear Emergency Management* (2006)	
S-98 rev.1	*Reliability Programs for Nuclear Power Plants* (2005)	x
S-99	*Reporting Requirements for Operating Nuclear Power Plants* (2003)	x
S-210	*Maintenance Programs for Nuclear Power Plants* (2007)	x
S-294	*Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* (2005)	x
S-296	*Environmental Protection Policies, Programs and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills* (2006)	x
S-298	*Nuclear Response Force Standard* (2003)	x
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-149	*Computer Programs Used in Design and Safety Analyses of Nuclear Power Plants and Research Reactors* (2000)	
G-205	*Entry to Protected and Inner Areas* (2003)	
G-206	*Financial Guarantees for the Decommissioning of Licensed Activities* (2000)	
G-208	*Transportation Security Plans for Category I, II or III Nuclear Material* (2003)	
G-217	*Licensee Public Information Programs* (2004)	
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-274	*Security Programs for Category I or II Nuclear Material or Certain Nuclear Facilities* (2003)	
G-276	*Human Factors Engineering Program Plans* (2003)	
G-278	*Human Factors Verification and Validation Plans* (2003)	
G-296	*Developing Environmental Protection Policies, Programs and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills* (2006)	
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)	

Table 2: CSA Documents Related to NPPs

Doc #	Document title	Status
N285.0	*General Requirements for Pressure-Retaining Systems and Components in CANDU Nuclear Power Plants* (2008)	x
N285.4	*Periodic Inspection of CANDU Nuclear Power Plant Components* (2009)	x
N285.5	*Periodic Inspection of CANDU Nuclear Power Plant Containment Components* (2008)	x
N285.6	*Material Standards for Reactor Components for CANDU Nuclear Power Plants* (2008)	x
N286.0	*Overall Quality Assurance Program Requirements for Nuclear Power Plants* (1992 reaffirmed 1998)	
N286	*Management System Requirements for Nuclear Power Plants* (2005)	x
N286.7	*Quality Assurance Of Analytical, Scientific And Design Computer Programs For Nuclear Power Plants* (1999 reaffirmed 2007)	x
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)	
N287.1	*General Requirements for Concrete Containment Structures for CANDU Nuclear Power Plants* (2009)	
N287.2	*Material Requirements for Concrete Containment Structures for CANDU Nuclear Power Plants* (2008)	
N287.3	*Design Requirements for Concrete Containment Structures for CANDU Nuclear Power Plants* (2009)	
N287.4	*Construction, Fabrication, and Installation Requirements for Concrete Containment Structures for CANDU Nuclear Power Plants* (2009)	
N287.5	*Examination and Testing Requirements for Concrete Containment Structures for CANDU Nuclear Power Plants*	
N287.6	*Re-Operational Proof and Leakage Rate Testing Requirements for Concrete Containment Structures for CANDU Nuclear Power Plants*	
N287.7	*In-service Examination and Testing Requirements for Concrete Containment Structures for CANDU Nuclear Power Plants* (2008)	x
N288.1	*Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities* (reaffirmed 2008)	x
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)	
N289.4	*Testing Procedures for Seismic Qualification of CANDU Nuclear Power Plants*	

Doc #	Document title	Status
N289.5	*Seismic Instrumentation Requirements for CANDU Nuclear Power Plants*	
N290.13	*Environmental Qualification of Equipment for CANDU Nuclear Power Plants* (2005 and Update 1 (2009))	x
N290.14	*Qualification of Pre-Developed Software for Use in Safety-Related Instrumentation and Control Applications in Nuclear Power Plants* (2007)	
N290.15	*Requirements For the Safe Operating Envelope for Nuclear Power Plants* (2010)	x
N290.5	*Requirements for Electrical Power and Instrument Air Systems of CANDU Nuclear Power Plants* (2008)	
N290.6	*Requirements for Monitoring and Display of Nuclear Power Plant Safety Functions in the Event of an Accident* (2009)	
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)	x
N293	*Fire Protection for CANDU Nuclear Power Plants* (2007, Consolidated)	x
N294	*Decommissioning of Facilities Containing Nuclear Substances* (2009)	x

Use of IAEA documents in CNSC regulatory documents

IAEA standards continue to serve as references and benchmarks for the Canadian regulatory framework documents, as they have for many years. The following table identifies some published CNSC regulatory documents that were developed using IAEA standards.

Table 3: CNSC Documents for NPPs that were developed using IAEA standards

CNSC document	Associated IAEA standard
RD-363, *Nuclear Security Officer Medical, Physical, and Psychological Fitness*	1. Safety Standards Series, NS-G-2.8
RD-353, *Testing the Implementation of Emergency Measures*	1. Safety Series No. 73 2. Safety Standards Series no. GS-R-2
RD-346, *Site Evaluation for New Nuclear Power Plants*	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

CNSC document	Associated IAEA standard
RD-337, *Design of New Nuclear Power Plants*	1. Safety standard series NS-R-1
RD-360, *Life Extension of Nuclear Power Plants*	1. Safety standards series No. NS-G-2.10
RD-336, *Accounting and Report of Nuclear Material (2010)*	1. IAEA INFCIRC/164
RD-204, *Certification of Persons Working at Nuclear Power Plants*	1. Safety guide No. NS-G-2.4 2. Safety guide No. NS-G-2.8
RD/GD-98, *Reliability Programs for Nuclear Power Plants (2012)*	1. IAEA TECDOC-524
RD/GD-210, *Maintenance Programs for Nuclear Power Plants (2012)*	1. TECDOC-658 2. Safety standards series, No. NS-G-2.6
S-294, *Probabilistic Safety Assessments (PSA) for Nuclear Power Plants*	1. Safety series No. 50-P-4 2. Safety series No. 50-P-8
S-210, *Maintenance Programs for Nuclear Power Plants*	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, *Keeping Radiation Exposures and Doses "As Low as Reasonably Achievable (ALARA)"*	1. Safety series No. 21 2. Safety series No. 102 3. Safety series No. 103

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 MW thermal. 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. The following CNSC regulatory documents related to small reactors were published during the reporting period:

- *Design of Small Reactor Facilities* (RD-367)
- *Deterministic Safety Analysis for Small Reactor Facilities* (RD-308)

They follow the same approach and structure as existing CNSC regulatory documents for large NPPs – *Design of New Nuclear Power Plants* (RD-337) and *Safety Analysis for Nuclear Power Plants* (RD-310).

The regulatory document addressing design requirements for small reactors (RD-367) identifies 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. Recognizing that some requirements may not be relevant to all types of facilities, RD-367 also includes 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 has similar requirements to CNSC document RD-337. However, it has 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 sets out the technical criteria against which the CNSC will review deterministic safety analysis for small reactors. These criteria assure that adequate safety analyses are completed for the siting, construction, operation and decommissioning of these reactors, in accordance with 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 allow 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 with which 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 levels 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

Table 1 indicates some of the areas that are covered by Type II inspections at NPPs.

Table 1: Specific areas of verification activities

Processes, functions and programs	Facilities and equipment
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 (table 2) for all currently operating reactors are stipulated in operating licence conditions that cite CNSC standard *Reporting Requirements for Operating Nuclear Power Plants* (S-99).

Table 2: Reports required from operating NPPs per S-99

Unscheduled reports		Periodic reports
Prompt preliminary reports followed by detailed reports	**Notifications and other reports**	
• non-compliances with the NSCA, regulations, orders, licence conditions • safety-significant non-compliances with licensing documents • deficiencies in records • events or incidents with significant implications for health and safety • releases • process failures • actuations, spurious operations and degradations of safety systems • degradations, excessive load conditions (observed or calculated), failures, configuration contraventions of pressure boundaries • reductions in effectiveness of reactor and turbine control systems • emergencies • external events • failures to perform tests required by the licence • failures to monitor or control releases of nuclear or hazardous substances • hazards not addressed in licensing documents • changes in financial status	• reaching of action levels • performance and status of certified personnel • problems identified by research or analysis	• operations • performance indicators • facility description and safety analysis updates • environmental monitoring • research and development progress • periodic inspections • degradation of pressure boundaries • reliability • fuel monitoring and inspection

Performance indicators

One of the periodic reports required by S-99, as indicated in table 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:

- 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 NPP performance as a whole, while some are more suited to measuring performance in specific programs. Specification sheets that provide the purpose and calculation method for the indicator, among other things, 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 that corrective or preventive measures can be taken. Reactive indicators prompt immediate action to correct deficiencies and prevent further deterioration.

The set of CNSC performance indicators is currently under review to augment the existing indicators with those that are commonly used by industry.

Annex 8
Overall CNSC Response to Fukushima

The CNSC fulfilled its post-Fukushima responsibilities at the national level by systematically conducting a series of high-level activities to address the lessons learned from the accident. Briefly, the CNSC:

1. issued a request to licensees to provide information pertinent to the Fukushima event
2. formed the CNSC Fukushima Task Force to coordinate the CNSC's assessment and response
3. gathered information on international lessons learned and the CNSC's own provisions to prevent and manage an event similar to Fukushima
4. developed criteria to help assess the licensees' information and the CNSC's provisions
5. performed the assessment, identified findings, made recommendations and documented them in a report
6. developed a detailed CNSC Action Plan to address the recommendations
7. consulted Canadians on both the initial Task Force report and the Action Plan
8. conducted IRRS Fukushima review and established an External Advisory Committee (EAC) to assess the organization's processes and responses to the lessons learned from Fukushima
9. created mechanisms to oversee the implementation of the CNSC Action Plan

The activities are described in the following subsections. For further details, see Canada's report to the Second Extraordinary Meeting of the CNS.

1. Request to licensees

In accordance with subsection 12(2) of the *General Nuclear Safety and Control Regulations*, the Executive Vice-President and Chief Regulatory Operations Officer of the CNSC wrote to all Class I nuclear facilities on March 17, 2011, directing the licensees to review initial lessons learned from Fukushima and re-examine the safety cases of their facilities, in particular the underlying defence-in-depth concept, and report on implementation plans for short-term and long-term measures to address any significant gaps.

2. CNSC Fukushima Task Force

The CNSC set up its Fukushima Task Force to coordinate a comprehensive evaluation of the operational, technical and regulatory implications of the Fukushima accident on Canadian NPPs. The Task Force Chair reported the results of the Task Force review to the Executive Vice-President and Chief Regulatory Operations Officer and the Commission.

3. Information gathering and assessment

The CNSC Fukushima Task Force assessed the lessons learned from the accident, as they were identified, the initial follow-up to those lessons, and the assessments of other countries and organizations. The Task Force reviewed the NPP licensees' responses to the letters described above. The Task Force also reviewed the existing regulatory provisions to prevent and manage an event similar to Fukushima, including the NSCA, its regulations, CNSC regulatory documents, NPP operating licences and elements of the compliance program.

4. Assessment criteria

The CNSC Fukushima Task Force developed *Nuclear Power Plant Safety Review Criteria* to define measurable expectations for each area of the assessment and aid the systematic identification of findings. The criteria were developed for application to Canadian NPPs and the nuclear regulatory framework but reflected international lessons and observations drawn from Fukushima. The criteria were applicable to the licensees' activities, the CNSC's activities and the CNSC's regulatory framework and covered the following review elements:

- NPP design for external hazards (see subsection 14(i) for details)
- impacts of beyond-design-basis accidents(see subsection 14(i) for details)
- accident management measures for beyond-design-basis accidents, including severe accidents (see subsection 19(iv) for details)
- emergency planning and response (see subsection 16.1 for details)
- regulatory framework and processes (see subsection 7.1 for details)

The criteria generally exceeded the applicable requirements and expectations of the current CNSC regulatory framework.

5. Task Force report

Using the criteria, the CNSC Fukushima Task Force assessed the substantial submissions provided by the licensees and also undertook a preliminary review of the regulatory framework for existing NPPs and potential new-build projects in Canada. The CNSC reviewed additional plans and concurred that the proposed enhancements have the potential to improve safety at the NPPs.

The Task Force summarized its assessments in the *CNSC Fukushima Task Force Report*. The findings applied to both licensees of operating NPPs and also any new-build project in Canada. The findings can be categorized into four groups:

- defence in depth
- emergency preparedness
- regulatory framework and processes
- international co-operation

6. CNSC Action Plan

Following the acceptance by the CNSC Executive Vice-President and Chief Regulatory Operations Officer of the draft *CNSC Fukushima Task Force Report*, the CNSC documented the *CNSC Management Response to the CNSC Fukushima Task Force Report*. The detailed CNSC Action Plan was then developed to ensure that the key recommendations in the *CNSC Fukushima Task Force Report* were addressed systematically and in a timely manner. The CNSC Action Plan was presented to the Commission and approved in 2012. At the end of this annex, table 1 provides a synopsis of actions taken by Canada and compares them with the elements of the *IAEA Action Plan on Nuclear Safety*. Later in the reporting period, the CNSC also created a strategic forum with the nuclear industry to discuss, on a quarterly basis, the progress in completing the CNSC Action Plan.

7. Consultation with public

There was extensive public consultation during the entire process described above. The *CNSC Fukushima Task Force Report* and the *CNSC Management Response to the CNSC Fukushima Task Force Report* were made available for public comment. The disposition of comments was part of the input into the CNSC Action Plan, which itself was provided for public comment. Finally, after addressing the comments on the CNSC Action Plan, it was provided for public comment a second time to provide an opportunity to comment on the changes made by CNSC staff to address the previous comments and the findings of the External Advisory Committee (EAC; see item 8, below).

8. External peer reviews

The CNSC was the subject of two, distinct assessments of its own response to Fukushima – the follow-up IRRS mission to Canada and the review by the EAC. In preparation for the IRRS follow-up mission to Canada in 2011, the CNSC requested the addition of the "Fukushima module" to the assessment by the peer-review team. Details are provided in the preamble of article 8.

The President of the CNSC established the EAC in 2011 to assess the organization's processes and responses in light of the lessons learned from Fukushima. The EAC comprised independent experts in energy, innovation, engineering, governance and safety from outside the nuclear sector. It assessed the CNSC independently from the IRRS review and the Task Force review.

The EAC reviewed the CNSC's processes, including the immediate response to the Fukushima incident, its connections with other government and international organizations, and its interactions with the Canadian nuclear sector and its regulated industries. It also reviewed the CNSC's communications with affected stakeholders, including governments, other nuclear regulators and the public. Finally, the EAC assessed the implications on the CNSC's regulatory approaches from the international response to Fukushima, such as international stress tests and the *IAEA Action Plan on Nuclear Safety*.

In its report to the CNSC in April 2012, the EAC concluded that the CNSC acted promptly and appropriately in the early stages of the Fukushima crisis and followed an appropriate process as it responded over time. The report included nine recommendations that complemented the findings of the Task Force. The CNSC accepted all the findings in the EAC report.

The EAC's recommendations can be sorted into three categories:

- application of Fukushima lessons to non-NPP facilities (outside the scope of this report)
- recommendations that align with actions already identified in the CNSC Action Plan (included several related to emergency preparedness; these are addressed in this report)
- communication and public education (see subsection 8.1(f) for details)

9. Mechanisms to oversee implementation of Fukushima-related actions

The CNSC created the Fukushima Safety Improvement Implementation Team in 2012 to oversee the implementation of the CNSC Action Plan by NPP licensees. The team is confirming the progress of the licensees, which is summarized in article 9. The team also compiled the closure criteria and expectations for its review of licensee submissions that address specific parts of the CNSC Action Plan. During the reporting period, the CNSC and NPP industry also created a strategic forum to discuss, on a quarterly basis, the progress in completing the CNSC Action Plan. All work is progressing, with all medium-term and long-term actions expected to be completed, per the plan, during the next reporting period.

Table 1: Synopsis of actions by Canada that correspond to the *IAEA Action Plan on Nuclear Safety*

<table>
<tr><th colspan="2">IAEA Action Plan on Nuclear Safety</th><th>Actions by Canada</th></tr>
<tr><td colspan="3">Action 1: Safety assessments in the light of the accident at TEPCO’s Fukushima Daiichi Nuclear Power Station
“Undertake assessment of the safety vulnerabilities of nuclear power plants in the light of lessons learned to date from the accident”</td></tr>
<tr><td>1.1</td><td>Member States to promptly undertake a national assessment of the design of nuclear power plants against site specific extreme natural hazards and to implement the necessary corrective actions in a timely manner.</td><td>Canada’s general approach to the assessment of the Fukushima lessons learned and the development of the CNSC Action Plan is well aligned to the broader objectives of the IAEA Action Plan on Nuclear Safety and its goals for enhanced global nuclear safety.

In March 2011, the CNSC issued a directive to all major Canadian nuclear facilities to re-examine the safety cases of NPPs, in particular underlying defence in depth, external hazards (including seismic, flooding, fire and extreme weather events), measures for prevention and mitigation of severe accidents, and emergency preparedness, and in order to report on necessary measures to address any significant gaps. A similar directive was issued to all uranium mills and mines and other important nuclear facilities.

The CNSC Fukushima Task Force was established in April 2011. The Task Force report was published in October 2011.

In August 2011, the president of the CNSC convened the EAC to provide an independent assessment of CNSC processes and responses to Fukushima.

The recommendations from the Task Force report and EAC report were incorporated into the CNSC Action Plan, which set out short-term (12 months), medium-term (24 months) and long-term (48 months) measures to address the gaps identified for NPPs. More recently, the CNSC issued the CNSC Integrated Action Plan to address the gaps identified for all major nuclear facilities in the following categories:
• strengthening of defence in depth
• enhancement of emergency response
• improvement of the regulatory framework and processes
• enhancement of international collaboration
• enhancement of communications and public consultation
• lessons learned with respect to human and organizational performance
All short-term actions have been fully addressed.</td></tr>
</table>

IAEA Action Plan on Nuclear Safety		Actions by Canada
1.2	The IAEA Secretariat, taking into account existing experiences, to develop a methodology and make it available for Member States that may wish to use it in carrying out their national assessments.	Given the technological differences in the CANDU designs, the CNSC Fukushima Task Force developed its own methodology for conducting safety reviews. The document *Nuclear Power Plant Safety Review Criteria* was made public in July 2011. The CNSC monitored the approaches taken by several international regulatory authorities, including the Western European Nuclear Regulators' Association (WENRA) "stress tests", to validate the approach taken in the development of its safety review criteria. Canada interacted actively with CANDU owner countries through COG and through bilateral exchanges, to assist or share information. Technical support was made available upon request. The CNSC, at the request of the Romanian Regulatory Authority, provided technical support in the conduct of its safety reviews in advance of evaluations by the European Union. In 2011, the CNSC hosted a peer-review team of experts for a follow-up IRRS mission that included a new review module dedicated to assessing the actions of the regulator in addressing the lessons learned from Fukushima. Canada was one of the first countries to be assessed against the IRRS Fukushima core module. The IRRS peer-review team found that CNSC actions and responses to the nuclear accident were prompt, comprehensive and robust. Specifically, the IRRS peer-review team rated the CNSC response to the Fukushima accident as a good practice.
1.3	The IAEA Secretariat, upon request, to provide assistance and support to Member States in the implementation of a national assessment of the design of nuclear power plants against site specific extreme natural hazards.	This is not directly applicable to Canada. The CNSC, as a member of the IAEA International Seismic Safety Centre, participates actively in the development of safety standards and safety reports addressing Fukushima-like extreme hazards and their impacts upon the safety of NPPs. CNSC participation is ongoing.
1.4	The IAEA Secretariat, upon request, to undertake peer reviews of national assessments and to provide additional support to Member States.	This is not directly applicable to Canada. The *CNSC Integrated Action Plan* required all major nuclear facility licensees to conduct a re-evaluation of site-specific seismic external hazards. The CNSC requested an IAEA International Seismic Safety Centre "Site & External Events Design" (SEED) review service for all NPPs. A pre-SEED mission to define the scope of review is expected in summer–fall of 2013 and a full SEED mission is

IAEA Action Plan on Nuclear Safety		Actions by Canada
		expected in late spring 2014.
Action 2: IAEA peer reviews "Strengthen IAEA peer reviews in order to maximize the benefits to Member States"		
2.1	The IAEA Secretariat to strengthen existing IAEA peer reviews by incorporating lessons learned and by ensuring that these reviews appropriately address regulatory effectiveness, operational safety, design safety, and emergency preparedness and response; Member States to provide experts for peer review missions.	Canada is a strong proponent of the IAEA peer-review process and contributes technical experts to IRRS missions and other reviews (Operational Safety Review Team (OSART), Integrated Nuclear Infrastructure Review (INIR) and Emergency Preparedness Review (EPREV), among others) and follow-up missions. Recent contributions included missions to the Russian Federation, China, Korea, the United States, Romania and Germany, among others. In January 2013, Canada participated in a technical meeting for IRRS team leaders and deputy team leaders (11 senior regulators were present) to share experience, improve implementation of IRRS missions and elucidate future expectations for the IRRS program. Several recommendations were made to the IAEA in its ongoing program to revise and continuously improve the IRRS program. In addition, the CNSC recently provided an expert structural engineer to support the IAEA international peer review of mid- and long-term roadmaps towards decommissioning of Fukushima Daiichi (completed in April 2013). A Working Group on Effectiveness and Transparency (WGET) was established by Contracting Parties to the CNS at the Second Extraordinary Meeting. WGET was mandated to report to the Sixth Review Meeting on a list of actions to strengthen the CNS and, where necessary, on proposals to amend the Convention. The WGET was to also take into consideration the overall output of the Second Extraordinary Meeting, including the initial proposals to amend the Convention that were submitted by Switzerland and the Russian Federation. Canada, as a member of the WGET, has assumed leadership for the preparation of two of fourteen working papers to be submitted to Contracting Parties in November 2013. The two papers coordinated by Canada will centre on international peer-review missions, and transparency and confidentiality issues. Work on the fourteen papers is ongoing.
2.2	The IAEA Secretariat, in order to enhance transparency, to provide summary information on where and when IAEA peer	This is not directly applicable to Canada. Canada is a strong advocate of openness and transparency in regards to making CNS and IRRS reports and follow-up responses available to the public on the CNSC Web site.

IAEA Action Plan on Nuclear Safety		Actions by Canada
	reviews have taken place, and to make publicly available in a timely manner the results of such reviews with the consent of the State concerned.	Canada is actively pursuing improvement initiatives in openness and transparency through its membership on the WGET. Canada has assumed leadership for the preparation of two of fourteen working papers to be submitted to Contracting Parties in November 2013. These two papers will centre on international peer-review missions, and transparency and confidentiality issues.
2.3	Member States to be strongly encouraged to voluntarily host IAEA peer reviews, including follow-up reviews, on a regular basis; the IAEA Secretariat to respond in a timely manner to requests for such reviews.	Canada hosted an IRRS mission in June 2009 and a follow-up mission in November 2011. The findings and measures undertaken to address these missions were made public. The results also figure prominently in Canada's national reports to the Fifth and Sixth Review Meetings and also to the Second Extraordinary Meeting of the CNS. Canada plans to host an EPREV in the 2014–15 time frame.
2.4	The IAEA Secretariat to assess, and enhance as necessary, the effectiveness of the IAEA peer reviews.	This is not directly applicable to Canada.
Action 3: Emergency preparedness and response "Strengthen emergency preparedness and response"		
3.1	Member States to conduct a prompt national review and thereafter regular reviews of their emergency preparedness and response arrangements and capabilities, with the IAEA Secretariat providing support and assistance through Emergency Preparedness Review (EPREV) missions, as requested.	The *CNSC Integrated Action Plan* addresses onsite emergency plans, the update of emergency facilities and equipment and offsite emergency plans and programs. Given the differing levels of oversight by other federal, provincial or municipal authorities that fall outside the purview of the CNSC, additional collaborative initiatives were introduced in the CNSC Action Plan to enhance collaboration and coordination between NPP operators and these authorities, for both onsite and offsite emergency preparedness programs. The CNSC imposed various actions on NPP licensees to assess and enhance onsite emergency response, including ones related to severe events and/or multi-unit accidents, the conduct of related emergency exercises and the adequacy of emergency facilities and equipment. The CNSC is collaborating with federal and provincial nuclear emergency planning authorities to: • ensure plan revisions are expedited and make regular full-scale exercises a priority • establish a formal, transparent, national-level oversight process for offsite nuclear emergency plans, programs and performance • review the planning basis of offsite arrangements with respect to multi-unit accident

IAEA Action Plan on Nuclear Safety		**Actions by Canada**
		scenarios • review arrangements for protective action including public alerting, validation of the effectiveness of potassium iodide (KI) pill-stocking and distribution strategies, and verifying or developing the capability for predicting, offsite effects • update the FNEP and validate it in a national-level exercise In addition, Health Canada revised the FNEP and integrated it with the FERP. Health Canada is revising its federal criteria for intervention in a nuclear emergency. A national nuclear emergency exercise is being developed for May 2014. Canada is planning to host an EPREV mission in the 2014–15 time frame.
3.2	The IAEA Secretariat, Member States and relevant international organizations to review and strengthen the international emergency preparedness and response framework, taking into account recommendations given in the final report of the International Action Plan for Strengthening the International Preparedness and Response System for Nuclear and Radiological Emergencies, and encouraging greater involvement of the relevant international organizations in the Joint Radiation Emergency Management Plan of the International Organizations.	Health Canada, on behalf of Canadian stakeholder government agencies, is participating in the: • IAEA Emergency Preparedness and Response Expert Group • IAEA Fukushima Comprehensive Assessment • IAEA International Radiation Monitoring Information System Technical Group • IAEA National Competent Authorities for the conventions on emergency notification and assistance • Comprehensive Nuclear Test-Ban Treaty Organization • Radiation Emergency Medical Preparedness and Assistance Network of the World Health Organization • *International Health Regulations* State Parties of the World Health Organization
3.3	The IAEA Secretariat, Member States and relevant international organizations to strengthen the assistance mechanisms to ensure that necessary assistance is made available promptly. Consideration to be given to enhancing and fully utilizing the IAEA Response and Assistance Network (RANET), including expanding its rapid response capabilities.	Health Canada is participating in RANET activities, has registered its biodosimetry response capability and is working with partners, including the CNSC, to identify additional capabilities that can be registered.

	IAEA Action Plan on Nuclear Safety	Actions by Canada
3.4	Member States to consider, on a voluntary basis, establishing national rapid response teams that could also be made available internationally through RANET.	Canada is not considering the establishment of an international rapid response team. However, Canada would provide assistance, when requested, through existing bilateral MoUs or international agreements, or within the RANET framework. The CNSC is following up on a recommendation from the CNSC Fukushima Task Force to enhance co-operation with other nuclear regulators in addressing the lessons learned from the Fukushima accident and thus further strengthening the capability to respond efficiently to any nuclear emergency.
3.5	The IAEA Secretariat, in case of a nuclear emergency and with the consent of the State concerned, to conduct timely fact-finding missions and to make the results publicly available.	This is not directly relevant to Canada.
Action 4: National regulatory bodies “Strengthen the effectiveness of national regulatory bodies”		
4.1	Member States to conduct a prompt national review and thereafter regular reviews of their regulatory bodies, including an assessment of their effective independence, adequacy of human and financial resources and the need for appropriate technical and scientific support, to fulfil their responsibilities.	Canada hosted an IRRS mission in 2009 that included a thorough peer review of the CNSC’s independence, adequacy of human and financial resources, and technical and scientific support. These areas were assessed to meet the relevant IAEA requirements, although there were four IRRS suggestions for improvement related to the use of advisory bodies (S4), recovery of regulatory costs (S2), organizational readiness for new-build projects (S9), and coordination of regulatory and technical staff to ensure the balanced consideration of safety and security issues (S3). There was also one good practice that recognized the CNSC’s ability to independently define its own employment conditions. Following Fukushima, Canada hosted a follow-up IRRS mission in 2011 that assessed the new (at that time) IRRS Fukushima core module and also reviewed the CNSC’s responses to the findings of the 2009 mission. The follow-up IRRS team reviewed the improvements that had been implemented and closed suggestions S4, S2, S9 and S3. There were no new findings related to regulatory independence, adequacy of human and financial resources, or technical and scientific support.

<table>
<tr><th colspan="2">IAEA Action Plan on Nuclear Safety</th><th>Actions by Canada</th></tr>
<tr><td>4.2</td><td>The IAEA Secretariat to enhance the Integrated Regulatory Review Service (IRRS) for peer review of regulatory effectiveness through a more comprehensive assessment of national regulations against IAEA Safety Standards.</td><td>This is not directly applicable to Canada, although Canada welcomes this initiative. The Canadian regulatory framework is based on IAEA safety standards and, where appropriate, integrates these into its legislative framework and supporting documentation.</td></tr>
<tr><td>4.3</td><td>Each Member State with nuclear power plants to voluntarily host, on a regular basis, an IAEA IRRS mission to assess its national regulatory framework. In addition, a follow-up mission to be conducted within three years of the main IRRS mission.</td><td>Canada hosted an IRRS mission in June 2009 and follow-up mission in November 2011.

Canada was one of the first countries to have its Fukushima safety reviews, overall assessment and action plan subjected to IAEA peer review through the Fukushima module of the IRRS follow-up review process.</td></tr>
<tr><td colspan="3">Action 5: Operating organizations
“Strengthen the effectiveness of operating organizations with respect to nuclear safety”</td></tr>
<tr><td>5.1</td><td>Member States to ensure improvement, as necessary, of management systems, safety culture, human resources management, and scientific and technical capacity in operating organizations; the IAEA Secretariat to provide assistance to Member States upon request.</td><td>The CNSC Integrated Action Plan incorporated measures within applicable actions to include consideration for human and organizational performance integral to all design, analysis and procedural activities that support all levels of defence in depth.

Recognizing that human and organizational performance (HOP) is fundamental to the lessons learned from Fukushima, the CNSC has integrated HOP-related lessons learned into the CNSC Integrated Action Plan, with a focus on:
integration of HOP-related aspects into the development of CNSC closure criteria for Fukushima actions, related to habitability requirements, training, usability, critical tasks completion times, SAMG validation, and emergency response roles and responsibilities.
continued development and revision of several CNSC regulatory documents to ensure human and organizational performance lessons learned from Fukushima are incorporated into the CNSC regulatory framework
The licensees’ implementation of HPO-related aspects is well advanced.</td></tr>
<tr><td>5.2</td><td>Each Member State with nuclear power plants to voluntarily host at least one IAEA Operational Safety Review Team (OSART) mission during the coming three years, with</td><td>Canada has participated in only one OSART mission and does not have plans for OSART conduct in the near future; this is premised on the fact that Canadian NPPs are subject to periodic WANO safety reviews. Greater openness and transparency of WANO reporting would provide input to regulatory oversight and, on this basis, Canada supports the</td></tr>
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IAEA Action Plan on Nuclear Safety		Actions by Canada
	the initial focus on older nuclear power plants. Thereafter, OSART missions to be voluntarily hosted on a regular basis.	ongoing initiatives of the IAEA and WANO to strengthen this aspect. The CNSC has initiated discussions with licensees and the IAEA Secretariat to consider the conduct of OSART missions in Canada once full implementation of the *CNSC Integrated Action Plan* is completed.
5.3	The IAEA Secretariat to strengthen cooperation with WANO by amending their Memorandum of Understanding to enhance information exchange on operating experience and on other relevant safety and engineering areas and, in consultation with other relevant stakeholders, to explore mechanisms to enhance communication and interaction among operating organizations.	Canada is a strong supporter of strengthened relationships between the IAEA and WANO and views this amended MoU as an added instrument to reinforce nuclear safety at operating nuclear facilities. Canadian NPP licensees share similar views and see this as an added means that demonstrates the effectiveness of self-monitoring and collaborative efforts among operating NPPs.
Action 6: IAEA Safety Standards "Review and strengthen IAEA Safety Standards and improve their implementation"		
6.1	The Commission on Safety Standards and the IAEA Secretariat to review, and revise as necessary using the existing process in a more efficient manner, the relevant IAEA Safety Standards in a prioritized sequence.	The CNSC continues to provide experts to the following groups to assist with the revisions of IAEA safety standards: • Commission on Safety Standards • Nuclear Safety Standards Committee • Radiation Safety Standards Committee • Transport Safety Standards Committee • Waste Safety Standards Committee • Nuclear Security Guidance Committee In 2012, CNSC staff participated in the drafting of Fukushima-related amendments to key specific requirements such as IAEA document *Safety of Nuclear Power Plants: Design Specific Safety Requirements* (SSR-2/1). The Canadian nuclear industry regularly participates in meetings of the Nuclear Safety Standards Committee and provides comments on proposed revisions to IAEA safety standards, which are reviewed and vetted by the CNSC prior to submission to the IAEA.

	IAEA Action Plan on Nuclear Safety	**Actions by Canada**
6.2	Member States to utilize as broadly and effectively as possible the IAEA Safety Standards in an open, timely and transparent manner. The IAEA Secretariat to continue providing support and assistance in the implementation of IAEA Safety Standards.	The Canadian regulatory framework is based on IAEA safety standards and has, where appropriate, integrated these within its legislative framework and regulatory oversight programs and processes. For example, the following IAEA documents provide general guidance for conducting PSAs in Canada: • *Development and Application of Level 1 Probabilistic Safety Assessment for Nuclear Power Plants* (SSG-3) • *Development and Application of Level 2 Probabilistic Safety Assessment for Nuclear Power Plants* (SSG-4) Canada has provided, and continues to provide, feedback on draft IAEA standards through its participation in the Commission on Safety Standards and its constituent safety standards committees.
Action 7: International legal framework "Improve the effectiveness of the international legal framework"		
7.1	States parties to explore mechanisms to enhance the effective implementation of the Convention on Nuclear Safety, the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management, the Convention on the Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, and to consider proposals made to amend the Convention on Nuclear Safety and the Convention on the Early Notification of a Nuclear Accident.	Canada is fully supportive of added initiatives by Contracting Parties to the CNS to enhance the effective implementation of the Convention and the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management. In that sense, Canada fully supports the Working Group of Experienced Officers of the two conventions to look at ways to improve the effectiveness of the international legal framework. Canada welcomes any initiative that leads to better and more effective processes, particularly those relating to improved effectiveness and greater efficiencies in the conduct of triennial review meetings. Canada continues to promote improvements to CNS effectiveness through its participation in the WGET formed by Contracting Parties at the Second Extraordinary Meeting to report at the Sixth Review Meeting on a list of actions to strengthen the CNS and on proposals to amend, where necessary, the Convention, taking into account the overall output of the Second Extraordinary Meeting and initial proposals to amend the Convention submitted by Contracting Parties. Canada has assumed the leadership of the development of two of fourteen topic papers selected by the WGET for consideration by the Contracting Parties at the Sixth Review Meeting: • Topic 3 – international peer-review missions • Topic 6 – transparency and confidentiality issues

IAEA Action Plan on Nuclear Safety		Actions by Canada
		These topics are consistent with Canada's position on openness and transparency, including the release to the public of all documentation related to peer reviews such as the CNS reviews and IRRS missions. Canada supports mechanisms to improve the effective implementation of the Conventions on Early Notification and Assistance, in particular through the Meeting of National Competent Authorities and as a RANET participant.
7.2	Member States to be encouraged to join and effectively implement these Conventions.	Canada is already a signatory to these conventions, together with codes of conduct on non-proliferation, research reactors and the safety and security of radioactive sealed sources, along with the *Comprehensive Nuclear Test-Ban Treaty*.
7.3	Member States to work towards establishing a global nuclear liability regime that addresses the concerns of all States that might be affected by a nuclear accident with a view to providing appropriate compensation for nuclear damage. The IAEA International Expert Group on Nuclear Liability (INLEX) to recommend actions to facilitate achievement of such a global regime. Member States to give due consideration to the possibility of joining the international nuclear liability instruments as a step toward achieving such a global regime.	The Government of Canada will continue to evaluate the benefits of joining an international nuclear civil liability convention to address the compensation and liability regime for nuclear damages arising from trans-boundary and transportation nuclear incidents. The modernization of Canada's domestic nuclear civil liability legislation remains a high priority. The Government has announced that it plans to table new legislation in the fall of 2013 that would significantly increase the current liability limits on operators of NPPs.
Action 8: Member States planning to embark on a nuclear power programme "Facilitate the development of the infrastructure necessary for Member States embarking on a nuclear power programme"		
8.1	Member States to create an appropriate nuclear infrastructure based on IAEA Safety Standards and other relevant guidance, and the IAEA Secretariat to provide assistance as may be requested.	Canada supports IAEA initiatives to promote and assist Member States planning to embark on nuclear power programs and has in the past responded to bilateral or IAEA requests for support to such programs. The CNSC is committed to assisting Member States in capacity building in either establishing or improving independent, effective regulatory programs. This includes hosting and conducting information, personnel and technical exchanges with Member

IAEA Action Plan on Nuclear Safety		Actions by Canada
		States considering new NPP programs. The CNSC actively contributes both information and expertise to MDEP. The CNSC is an active member of the IAEA's Regulatory Cooperation Forum and will continue to participate as the number of countries embarking on nuclear power programs grows. In 2012, CNSC continued to provide follow-up support to the Jordan Nuclear Regulatory Commission at meetings of the Regulatory Cooperation Forum. The CNSC periodically conducts personnel and technical exchanges with Member States seeking information. For example, in 2012, CNSC staff hosted two representatives from the Indonesian regulator BAPETEN at CNSC headquarters for two months as part of its overall preparations to regulate NPPs. The two representatives focused their attention on CNSC processes for reviewing EAs and licence applications for new NPPs. In 2012, CNSC also continued to provide regulatory technical support to the Romanian government during the Fukushima stress test evaluation of their CANDU 6 units at Cernavoda and to provide technical assistance in its preparation for European Union peer reviews. Most recently, the CNSC has provided a senior technical advisor to Canada's Permanent Mission in Vienna to act as nuclear safety liaison and to provide cost-free support for the implementation of the *IAEA Action Plan on Nuclear Safety*. The CNSC has, in addition, hosted IAEA Fellows requesting information exchanges on uranium mining and milling and provided training to other Member States in the safety and security of nuclear materials.
8.2	Member States to voluntarily host Integrated Nuclear Infrastructure Reviews (INIR) and relevant peer review missions, including site and design safety reviews, prior to commissioning the first nuclear power plant.	CNSC staff are available to participate in INIR missions.
Action 9: Capacity building "Strengthen and maintain capacity building"		
9.1	Member States with nuclear power programmes and those planning to embark on such a programme to strengthen,	The CNSC has optimized its workforce to meet its current and anticipated regulatory needs. Programs are in place for the systematic identification of training needs and training delivery. The CNSC has developed and enhanced specific programs related to inspector

	IAEA Action Plan on Nuclear Safety	**Actions by Canada**
	develop, maintain and implement their capacity building programs, including education, training and exercises at the national, regional and international levels; to continuously ensure sufficient and competent human resources necessary to assume their responsibility for safe, responsible and sustainable use of nuclear technologies; the IAEA Secretariat to assist as requested. Such programmes to cover all the nuclear safety related areas, including safe operation, emergency preparedness and response and regulatory effectiveness and to build upon existing capacity building infrastructures.	training and qualification, leadership development, and orientation of new employees. The CNSC is placing a stronger emphasis on emergency exercises that test the capabilities of personnel and the working relationships and communications between the various responsible authorities. The authorities at all levels are planning to conduct, in conjunction with the licensee, a full-scale, NPP-based, national-level emergency exercise in 2014. The CNSC has set requirements for NPP licensees related to training programs, the identification of the minimum shift complement and the certification of certified personnel. The CNSC uses inspections and desktop reviews to confirm that licence applicants and licensees meet these requirements. The NPP licensees also have various programs to ensure the adequacy and improvement of human resources. These include a systematic approach to the identification of training needs and training delivery, administration of examinations for certification and requalification, workforce capability analysis and knowledge retention and hiring programs. The licensees conduct significant recruiting activities at universities and community colleges, as well as outreach to groups such as Women in Nuclear and North American Young Generation in Nuclear. In terms of education, Canadian universities offer numerous programs in science and engineering and some of them also offer nuclear engineering programs. The University of Ontario Institute of Technology has shaped a nuclear engineering program to specifically meet industry needs. The University Network of Excellence in Nuclear Engineering is an alliance of universities and NPP licensees, as well as research and regulatory agencies, that supports and develops nuclear education and R&D capability in Canadian universities. Its main objective is to assure a sustainable supply of qualified nuclear engineers and scientists to meet the current and future needs of the Canadian nuclear industry. In terms of strengthening the capacity of Member States embarking on nuclear power programs, Canada has shared its findings and lessons learned with international peers, through the Second Extraordinary Meeting of the CNS and by participation at various fora such as meetings of CANDU Senior Regulators and the International Nuclear Regulators Association.
9.2	Member States with nuclear power programmes and those planning to embark on such a programme, to incorporate	Shortly after the Fukushima accident, the CNSC conducted and completed an assessment of the safety vulnerabilities of NPPs in light of the lessons learned and released the *CNSC Fukushima Task Force Report* in October 2011.

	IAEA Action Plan on Nuclear Safety	**Actions by Canada**
	lessons learned from the accident into their nuclear power programme infrastructure; the IAEA Secretariat to assist as requested.	Additionally, the EAC was established to conduct an independent review of the CNSC's immediate response to Fukushima. The EAC found that the CNSC acted promptly and appropriately to the Fukushima crisis and made additional recommendations to enhance communications and transparency with the public, extend the applicability of certain elements of the CNSC Action Plan to non-NPPs and provide further consideration of HOP, where applicable, to certain elements of the CNSC Action Plan. The measures implemented by Canada through the *CNSC Integrated Action Plan* to strengthen defence in depth, enhance emergency preparedness, improve its regulatory framework and processes and enhance international collaboration within the 48-month implementation timeline fully address the gaps identified through its safety reviews. In general, the recommended measures can be categorized as actions related to: • NPPs • major nuclear facilities other than NPPs • communication and public education • lessons learned with respect to HOP The *CNSC Integrated Action Plan* has addressed all recommendations from CNSC Fukushima Task Force safety reviews, the EAC report and suggestions from the IRRS follow-up mission. All short-term actions have been completed by licensees and it is expected that the remaining medium- and long-term actions will be completed by December 2013 and December 2015, respectively. Regulatory framework enhancements, including legislative amendments, which take into consideration those additional safety measures required of Canadian NPPs as a result of lessons learned from Fukushima, were introduced in relevant new-build regulatory documents. New-build or refurbishment projects will be required to meet updated regulatory requirements that include lessons learned from Fukushima.
Action 10: Protection of people and the environment from ionizing radiation "Ensure the on-going protection of people and the environment from ionizing radiation following a nuclear emergency"		
10.1	Member States, the IAEA Secretariat and other relevant stakeholders to facilitate the use of available information, expertise and techniques for monitoring, decontamination	Canada is participating in relevant expert meetings and groups, including the International Radiation Monitoring Information System, to create a global monitoring network. The diversification and upgrade of capabilities of the FNEP Technical Advisory Groups continues to ensure and provide supportive overlap of national capabilities.

	IAEA Action Plan on Nuclear Safety	Actions by Canada
	and remediation both on and off nuclear sites and the IAEA Secretariat to consider strategies and programmes to improve knowledge and strengthen capabilities in these areas.	The CNSC and Health Canada are reviewing the existing Canadian guidance on radioactively contaminated food and water following a nuclear emergency against international guidance and lessons learned from Fukushima. They are also reviewing international recommendations with respect to recovery phase actions, with a focus on rehabilitation and relocation.
10.2	Member States, the IAEA Secretariat and other relevant stakeholders to facilitate the use of available information, expertise and techniques regarding the removal of damaged nuclear fuel and the management and disposal of radioactive waste resulting from a nuclear emergency.	Canada participated in relevant expert meetings and groups, including the IAEA's International Experts Meeting on Decommissioning and Remediation after a Nuclear Accident, and a CSA workshop on site cleanup criteria. The CNSC is collaborating with other federal and provincial regulators to establish cleanup criteria in the event of a nuclear accident. Canada is reviewing the cleanup criteria used by other countries, as well as international benchmarks used by the ICRP, the World Health Organization and the IAEA Basic Safety Standards. Canada is participating in international discussions on decommissioning and remediation and on establishing cleanup criteria.
10.3	Member States, the IAEA Secretariat and other relevant stakeholders to share information regarding the assessment of radiation doses and any associated impacts on people and the environment.	Canada is participating in international activities associated with the assessment of doses and impacts on the environment through such organizations as the IAEA and the United Nations Scientific Committee on the Effects of Atomic Radiation. Health Canada is participating in the International Radiation Monitoring Information System to make its cross-Canada monitoring data available to participating countries in real time. Environment Canada, as a Regional Specialized Meteorological Centre to the World Meteorological Organization, continues to collaborate with that organization and the IAEA to strengthen the assessment and sharing of meteorological information for nuclear emergency response.
Action 11: Communication and information dissemination "Enhance transparency and effectiveness of communication and improve dissemination of information"		
11.1	Member States, with the assistance of the IAEA Secretariat, to strengthen the emergency notification system, and reporting and information sharing	Canada supports mechanisms to improve rapid and coordinated information exchange, and in particular through the new IAEA emergency communications protocols and ongoing use and enhancement of the Unified System for Information Exchange. Canada has registered all relevant emergency notification contact points with the IAEA.

	IAEA Action Plan on Nuclear Safety	**Actions by Canada**
	arrangements and capabilities.	
11.2	Member States, with the assistance of the IAEA Secretariat, to enhance the transparency and effectiveness of communication among operators, regulators and various international organizations, and strengthen the IAEA's coordinating role in this regard, underlining that the freest possible flow and wide dissemination of safety related technical and technological information enhances nuclear safety.	Canada fully supports this initiative and has assumed a leadership role in the development of topics for consideration by Contracting Parties at the Sixth Review Meeting. Canada will focus on openness and transparency – in particular, the public availability of CNS reports, CNS peer-review questions, IRRS mission reports and follow-up plans to address IRRS recommendations and suggestions. In addition, strategies will be proposed for greater openness during the conduct of the review meetings, along with instruments that may lead to fewer citations of security- and confidentiality-related concerns as reasons for weakening or delaying critical actions.
11.3	The IAEA Secretariat to provide Member States, international organizations and the general public with timely, clear, factually correct, objective and easily understandable information during a nuclear emergency on its potential consequences, including analysis of available information and prognosis of possible scenarios based on evidence, scientific knowledge and the capabilities of Member States.	This is not directly applicable to Canada. Canada supports the extended mandate of the IAEA for providing technical assessment during a nuclear emergency, and encourages the IAEA Secretariat to work with Member States to coordinate and benchmark technical assessment capabilities and to develop procedures for coordinating and communicating results to Member States. Following the Fukushima accident, the CNSC played a central role in communicating with Canadians and international colleagues on the impacts arising from the accident and steps being taken to respond to the accident. As part of these steps, the CNSC also developed a crisis Web site to help respond to future crises or emergencies. The site is to be activated if a Canadian or international nuclear emergency, incident or accident occurs that would pose a significant risk to any Canadian community, or where there is significant media and public concern. When activated, the crisis site becomes the primary access site to all visitors to the CNSC Web site. The crisis site provides a quick and easy way for the CNSC to get its response out early and clearly and assures the public that the CNSC is taking the situation seriously. In August 2012, the CNSC approved the architecture of the crisis Web site that is now ready for activation as a means of keeping the media, employees, the public and stakeholders informed during a nuclear crisis or emergency at a federally regulated facility. The *CNSC Integrated Action Plan* includes several measures to promote both domestic

IAEA Action Plan on Nuclear Safety		Actions by Canada
		and international strategies to inform the public on nuclear safety. Canada participated as co-chair in the IAEA International Experts Meeting in May 2012 on enhancing transparency and communications effectiveness in the event of a nuclear emergency. In addition, the CNSC has increased its Web presence and developed several education tools that are available to the public to foster a greater understanding of the uses of nuclear energy and the measures in place to promote nuclear safety and protect workers, the public and the environment.
11.4	The IAEA Secretariat to organize international experts meetings to analyse all relevant technical aspects and learn the lessons from the Fukushima Daiichi nuclear power station accident.	The IAEA has organized five International Expert Meetings as a follow-up to the accident at Fukushima. The CNSC and the Canadian nuclear industry have attended and made presentations at most of these meetings. Canada participated at the Fukushima Ministerial Conference in Japan in December 2012 and chaired one of the sessions. Canada is also participating in the development of the IAEA Comprehensive Fukushima Report and is contributing by providing: • a co-chair to one of the working groups • an external expert in support of Working Group 1 • a senior technical advisor to serve on the International Technical Advisory Group formed to assist in the review and formulation of technical/scientific aspects and accuracy of the report
11.5	The IAEA Secretariat to facilitate and to continue sharing with Member States a fully transparent assessment of the accident at TEPCO's Fukushima Daiichi Nuclear Power Station, in cooperation with Japan.	Canada supports this initiative. Canada is contributing to the development of the IAEA's Comprehensive Fukushima Report.
11.6	The IAEA Secretariat and Member States, in consultation with the OECD/NEA and the IAEA International Nuclear and Radiological Event Scale (INES) Advisory Committee to review the application of the INES scale as a communication tool.	Canada is a member of the INES Advisory Committee and has been an active participant in ongoing initiatives to draft a guidance document on communicating INES ratings during severe accidents, and in the construction of distant learning modules.

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<tr><th colspan="2">IAEA Action Plan on Nuclear Safety</th><th>Actions by Canada</th></tr>
<tr><td colspan="3">Action 12: Research and development
“Effectively utilize research and development”</td></tr>
<tr><td>12.1</td><td>Relevant stakeholders, with assistance provided by the IAEA Secretariat as appropriate, to conduct necessary research and development in nuclear safety, technology and engineering, including that related to existing and new design-specific aspects.</td><td>Canada has evaluated specific research needs as indicated by the Fukushima accident progression and consequences. While no major knowledge gaps have been identified, the plans and priorities of research activities have been adjusted to include subjects such as:
• dedicated instrumentation
• source term predictions
• in-vessel retention versus the use of refractory materials at the bottom of the EC6 reactor vault to delay compromised core integrity</td></tr>
<tr><td>12.2</td><td>Relevant stakeholders and the IAEA Secretariat to utilize the results of research and development and to share them, as appropriate, to the benefit of all Member States.</td><td>The generators of the relevant R&D (e.g., COG, the CNSC, or Candu Energy) share the results as appropriate. For example, COG information and results are available to its members. All relevant bodies participate in technical fora and information-sharing mechanisms such as MDEP. The CNSC also shares information through the CANDU Senior Regulators Group.</td></tr>
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Annex 9 (c)
Public Information Programs of NPP Licensees

The licensees' public information programs typically consist of the following elements:

- "commitment to openness" policy statements to identify the key target region around the NPP
- publication of operational milestones and news to attract media attention
- quarterly community update brochures mailed to households in the region
- stakeholder mailing list to provide all key corporate publications and a monthly update
- programs for quarterly stakeholder information sessions
- regular updates provided to county councils, local politicians at the municipal, provincial and federal levels
- visitors' centre outreach program (general public, advertising, information, schools)
- annual open house on annual performance
- Aboriginal affairs program
- communications with employees
- information availability portals at local libraries
- information sessions annually on topics identified as areas of public interest
- public polling and focus groups to gather information on public opinion
- frequently updated company Web site for media releases, disclosure of information of interest to the public, and provision of extensive information to the public on a number of topical areas related to the use of nuclear power

As an example, OPG conducted a comprehensive outreach program during the reporting period related to the Darlington new-build project. The outreach activities included the following:

- regular project newsletters to over 95,000 households and businesses in Clarington and Oshawa
- regular meetings of the Darlington Planning and Infrastructure Information Sharing Committee regarding other planned projects in South Clarington (committee now replaced by a Traffic Management Working Group)
- regular updates (letters and briefings) to Durham Regional Council and Clarington and Oshawa municipal councils
- regular updates to existing community committees (Durham Nuclear Health Committee, Darlington Community Advisory Council), as well as other stakeholders
- information-sharing events with First Nations and Métis communities to discuss the implementation of OPG's policy on First Nation and Métis relations

OPG maintains the Host Municipal Agreement for the Darlington New Nuclear Project with the Municipality of Clarington and continues discussions with the Regional Municipality of Durham regarding the same.

OPG also undertook an extensive stakeholder engagement program in support of the pre-construction licence application request for acceptance of OPG's decision regarding an assessment of condenser cooling options for the new-build project at Darlington (see annex 17 for technical details). The purpose was to provide the public and stakeholders with information regarding the best available technology economically achievable (BATEA) assessment and the results so that they might be informed and aware of OPG's plans. The program was also intended to provide stakeholders and the public with an opportunity to participate in the assessment by reviewing and confirming the factual basis of the evaluation and confirming the accuracy of assumptions used in the evaluation of attributes.

OPG continues to maintain the Darlington New Nuclear Project Web site and posted its *Nuclear Public Information Disclosure and Transparency Protocol* in January 2013.

Annex 10 (a)
Safety Policies at the Nuclear Power Plants

As stated in article 10, each NPP licensee in Canada has established, as part of its management system, an overriding priority to safety.

Each licensee 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 the following:

> 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 to the Chief Executive Officer and the Board of Directors to establish a management system that fosters nuclear safety as the overriding priority.

Ensuring a healthy nuclear safety culture is part of the Bruce Power management system (which is described in annex 13(a)) as an objective and a means to high standards of excellence. The Bruce Power nuclear safety policy states the following:

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

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 the following 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 follows:

> 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 NBPN 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 specifies 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 can issue licences only 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.

The NSCA provides the legislative basis for the qualification, training, examination and certification of personnel. In addition, the *General Nuclear Safety and Control Regulations* specify that the licensee shall:

(a) ensure the presence of a sufficient number of qualified workers to carry on the licensed activity safely and in accordance with the Act, the regulations made under the Act and the licence;

(b) train the workers to carry on the licensed activity in accordance with the Act, the regulations made under the Act and the licence

The *Class I Nuclear Facilities Regulations* require each applicant for a licence to construct, operate, or decommission the facility to provide details about the qualifications, training and experience of any worker involved in the operation or maintenance of the NPP.

The following requirements, included in licences to operate NPPs, are 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 ensure adequate emergency response capability. The minimum complement is specified in licensee documents.
- 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 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 positions, as specified in the CNSC document *Certification of Persons Working at Nuclear Power Plants* (RD-204), which is cited in the licences to operate the existing NPPs.

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 analyzed 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 the assistance of external consultants, that gives Bruce Power a comprehensive view of the potential improvements that can be implemented to optimize its workforce. This information was used to develop a workforce planning process that is reviewed annually as part of the business planning cycle.

The workforce planning process leverages the 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 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 or 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. Senior managers also review the status of Bruce Power’s planned staffing efforts and other critical reports semi-monthly.

This experience, knowledge and continual review 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 the site for each year of the planning horizon. 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.

Annex 12 (a)
Responsibilities and Accountabilities for Human Performance at NPPs

Each licensee incorporates, in its management system, an organizational and management philosophy that uses a hierarchical method to account for human performance:

- The primary responsibility for human performance rests with each individual.
- First-line managers are accountable for monitoring and correcting human performance issues.
- Management provides the necessary expectations, facilities and tools to aid human performance.
- Non-line organizations provide independent oversight of human performance.

The priority to safety of each licensee and the focus on safety culture (discussed in article 10) are critical to this hierarchical approach. Clear lines of authority and communication are established, so that individuals throughout the organization are aware of their responsibilities toward nuclear safety. At the individual level, the emphasis is on personal dedication and accountability for each individual engaged in an activity that affects the safety of the NPP. An individual's recognition and understanding of this responsibility, as well as a questioning and self-checking attitude, are essential for minimizing human errors.

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.

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
- 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
- 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 9(b), 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 and QA 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 in those areas where the most significant impact will be achieved. The program also provides guidance on effective non-confrontational approaches to interacting with employees when delivering coaching feedback on performance that met or did not meet standards.

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 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. HFE program plans are produced to identify the HFE activities. The plans are based on the regulatory requirements, international standards and best practices and 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. HFE summary reports are produced to document the results of the human factors process.

The HFE program plan for design aspects of a refurbishment project covers 11 elements (based on the USNRC NUREG 0711, Human Factors Engineering Program Review model):

- HFE program management
- OPEX review
- functional requirements analysis and function allocation
- task analysis
- staffing and qualification
- human reliability analysis
- human-system interface design
- procedure development
- training program development
- human factors verification and validation
- design implementation (integration)

In addition to providing input to the design itself, human factors are also addressed as part of the constructability, operability, maintainability and safety review as well as in the development of procedures, instructions and training.

Annex 13 (a)
Example of an NPP Management System

This annex describes, for illustrative purposes, the management system of Bruce Power.

Nuclear safety is a primary consideration for Bruce Power. Therefore, its management system must support the enhancement and improvement of safety culture and the achievement of high levels of safety as well as business performance. The Bruce Power management system (BPMS) was designed to ensure the Bruce Power leadership team can consistently deliver expected results and satisfy key stakeholders such as the CNSC, the public, its shareholders and employees. It ensures that Bruce Power meets the requirements of its operating licences, other applicable codes, standards, legal and business requirements.

Bruce Power operates as a private sector company within a competitive electricity market. As such, it has an obligation to shareholders for operating 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.

Bruce Power's Chief Executive Officer is the owner of the BPMS and commits the company to adhering to its requirements. It is an expectation that the leadership, management and staff of Bruce Power be individually and collectively committed to the BPMS and perform within its requirements and principles. Clearly defined ownership, responsibilities, authorities and accountabilities are essential. The BPMS describes and reinforces this by using a governance-oversight-support-perform model.

The BPMS is intended to address the totality of Bruce Power's business (not just those aspects over which any particular regulatory body has jurisdiction). The BPMS enables compliance with requirements or standards that Bruce Power has adopted, either voluntarily, as a condition of doing business in Canada and Ontario, or as required by law, regulation or convention.

CSA standard *Management System Requirements for Nuclear Power Plants* (N286-05) is used as the primary standard against which the BPMS is designed. The BPMS is structured around five components, based on a plan-do-check-act cycle and the principles in CSA N286:

- strategic direction
- policy, program and process controls
- process management
- business planning and monitoring for results
- leadership and organizational accountability

The BPMS applies to the entire business, at all locations managed by the organization. It is designed with flexibility to ensure it can be adapted as the business evolves. The BPMS is periodically reviewed, assessed and revised. The processes are regularly assessed to identify gaps and opportunities for improvement based on self-evaluation, review of external good practice and evolving standards.

By design, the BPMS contributes to the establishment of a nuclear safety culture that assures reactor, environmental, industrial and radiological safety. It also provides guidance for making risk-based decisions that satisfy the desired balance between safety, commercial, corporate reputation and other performance requirements. No single element of the BPMS operates independently; all its parts are interconnected and interdependent. A graded approach is used throughout the BPMS. The degree to which management system requirements are applied reflects the importance of the activity to safety, health, environmental, security, quality, economic or other business requirements. Where a graded approach is adopted, the grading process is documented, with safety being the paramount consideration for guiding decisions and actions. The BPMS describes how performance objectives are established and implemented.

Bruce Power is on the path of achieving an integrated, process-based approach to the BPMS, which addresses all elements of the business including safety, health, environmental, security, quality and economic elements, by providing a single framework for the arrangements of processes necessary to address the goals of the organization.

Annex 13 (b)
Update on QA Measures for Pressure Boundary Work

Previous 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 were limiting some licensees’ authorization to perform pressure-boundary work and/or requiring them to subcontract fabrication work to certified companies. Below is the status on the issuance of certificates of authorization to NPP licensees allowing them to perform pressure boundary work.

For Bruce A and B, the Ontario provincial authority issues multiple certificates of authorization to Bruce Power that are maintained through its pressure boundary QA program. These certificates were renewed for a three-year period in April 2010 and again in 2013 after 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 Ontario provincial authority for certain nuclear and non-nuclear fabrication and installation activities. These certificates were allowed to expire in 2013 at the end of the project.

In 2004, OPG applied for certificates of authorization for pressure boundary work (repairs, replacements, modifications and fabrications to its non-nuclear and nuclear pressure-retaining boundaries). The Ontario provincial authority found that OPG had successfully addressed new requirements for its QA programs. It subsequently awarded nine certificates of authorization to each site at Pickering and Darlington to cover the various scopes of work.

At Gentilly-2, the new QA program relating to the pressure-retaining systems and components was implemented by Hydro-Québec in September 2012. At the end of the reporting period, Hydro-Québec was rolling out the new program. An audit of the new internal process will be performed during the third quarter of 2013. Hydro-Québec was also issued multiple certificates of authorization by the provincial authority, which are maintained within the pressure boundary QA program.

At Point Lepreau during the reporting period, the authorized inspection agency assessed NBPN’s pressure boundary QA program for compliance with the required elements and issued a certificate of registration to Point Lepreau. Also during this period, the program was updated to reflect the 2007 edition of ANSI/NB 23 requirements.

Annex 14 (i) (c)
Details on Deterministic Safety Analysis

Content of the safety analysis reports for existing NPPs

The typical safety analysis report is organized into three parts, each of which deals with a separate aspect of the 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
- geography and land use for recreation and commerce, as well as information such as population distribution
- meteorology
- hydrology
- geology and seismology

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

Examples of improvements to deterministic safety analyses

During the reporting period, Bruce Power updated its safety analysis to take into account the effects of aging of the heat transport system. As mentioned in subsection 14(i)(c), Bruce Power aligned the analysis for loss of flow events at Bruce A with the new requirements in *Safety Analysis for Nuclear Power Plants* (RD-310) and accounted for heat transport system aging. Bruce Power also updated its analysis of a large loss-of-coolant accident in conjunction with a loss of emergency coolant injection. Bruce Power considered aging effects in the analysis and used best estimate methods to identify credible hydrogen and fission product source terms. Bruce Power included the bounding dose consequences for this dual-failure accident in the updates of the safety reports for Bruce A and Bruce B.

Bruce Power also updated the descriptions in Part 1 (plant and site description) and Part 2 (plant components and systems) of the Bruce A safety report to reflect the numerous modifications made during the refurbishment of Bruce A Units 1 and 2.

OPG conducted the following re-analyses of design-basis accidents during the reporting period, which took into account the effects of reactor aging:

- A new neutron-overpower methodology (where modelling and operational uncertainties are formally calculated) was used to confirm that the safety margins for loss-of-regulation scenarios remain acceptable.
- Loss-of-flow and small-break loss-of-coolant accidents were re-analyzed to incorporate the modelling of aged pressure tubes in the fuel channels. The results indicated that aging is having a small but negative impact on safety margins. OPG is implementing modifications to restore the affected margins, as necessary.

OPG also used best estimate methods (involving a more realistic break-opening time) and best estimate and uncertainty methods to demonstrate that the consequences of the large loss-of-coolant accident remain acceptable and are, in fact, less severe than previously estimated.

NPP licensees have performed, or are planning to perform, deterministic analyses for representative severe core damage accidents, as described in subsection 14(i)(c). OPG also conducted severe accident analysis to predict the impact of the installation of passive auto-catalytic recombiners (PARs) on potential hydrogen production.

Annex 14 (i) (d)
Status of Probabilistic Safety Assessments at Each Nuclear Power Plant

Licensees of existing NPPs are currently updating, or have already updated, their probabilistic safety assessments (PSAs) to meet the requirements of the CNSC regulatory document *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* (S-294), which is cited in their licences to operate[9].

Some licensees have conducted a PSA-based seismic margin assessment, which 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. It follows the same procedure and steps as those of the seismic PSA, except for the treatment of seismic hazard information. Since the PSA-based seismic margin assessment does not consider the seismic hazard explicitly, it does not estimate severe core damage. Instead, it produces such results as the seismic capacity and random failure probability, assuming that a seismic event occurs. In this method, a 0.3 g review-level earthquake is specified for most plants east of the Rocky Mountains and is validated against median hazard curves from a 1984 study so as to represent earthquake magnitudes with an approximate 10,000-year recurrence rate.

The major driving force to adopt the PSA-based seismic margin assessment was the large uncertainty in the seismic hazard. Past seismic PSA experiences indicate 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 made the decision-making process quite challenging. Consequently, it was proposed to use the PSA-based seismic margin assessment.

Bruce A and B

The Bruce A and B PSAs were completed in the period from 2003 to 2006. During that time, Bruce A completed PSA-based seismic margin assessments using a review-level earthquake with a recurrence interval of 10,000 years. The Bruce B initial PSA was completed in 1999 and updated every two years.

Bruce Power is currently implementing a plan to meet the requirements of S-294, which include the following:

- development of methodology guides for Level 1 and Level 2 PSAs and for seismic, fire, flood and external events
- completion of PSA-based seismic margin assessment for Bruce A and B
- update of Level 1 and Level 2 PSAs with site-specific data
- integration of Level 1 and Level 2 PSAs
- submission to the CNSC of external events models

Bruce Power has completed development of the PSA methodologies, is upgrading the Bruce A and B Level 1 PSAs and is completing the models for the Level 2 PSA at power.

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[9] AECL performed a Level 1 and Level 2 PSA for NRU in 2007; it was accepted by the CNSC during the reporting period.

By the end of 2013, Bruce Power expects to fully integrate the Level 1 and Level 2 PSA models and develop the external events models. Bruce Power is also developing an assessment methodology for tornadoes as part of its PSA update.

OPG (general to Pickering and Darlington)

OPG developed a Level 1 PSA methodology applicable to Pickering A and B and Darlington, which was accepted by the CNSC. Pickering A and B and Darlington developed, in concert with EPRI, a PSA methodology to assess seismically induced fires and floods. Pickering is also developing an assessment methodology for tornadoes as part of its PSA update.

Pickering A

In 1995, a PSA was completed for Pickering A. The PSA covered both Levels 1 and 2 for internal events with the units at high power and shutdown. In 1997, Pickering A also conducted a seismic margin assessment. The PSA was revised in 2006 for the restart of Units 1 and 4, addressing Levels 1 and 2. The Level 1 portion was again revised in 2009 to reflect design changes and modifications related to the safe storage of Units 2 and 3 that affected Units 1 and 4. OPG is currently updating the PSA in accordance with S-294, and all the elements are to be complete by December 2014. OPG is also completing a PSA-based seismic margin assessment for Pickering A, using a review level earthquake with a recurrence interval of 10,000 years.

Pickering B

A PSA was completed for Pickering B in 2006, which covered both Levels 1 and 2 for internal events with the units at high power. The Level 1 and Level 2 portions of the PSA were revised in 2007 to accommodate design changes and improvements in methodology and operating experience.

The Pickering B PSA was comprehensively revised to be in full compliance with S-294 and includes a PSA-based seismic margin assessment using an earthquake with an approximately 10,000-year recurrence interval. The PSA was completed and submitted to the CNSC by December 2012.

Darlington

A PSA was completed for Darlington during its design and construction phase in the late 1980s. An interim revision to the PSA was completed in 2001, incorporating design changes and operating experience.

OPG completed a full-scope PSA compliant with S-294 in 2011. This revision included:

- an update of methodology to industry standards and current Canadian regulatory standards, including S-294
- incorporation of design changes and operating experience
- expansion of the scope to include assessments for internal fires, internal floods, seismic events (i.e., seismic PSA) and other external events (e.g., airplane impact)
- assessments for shutdown and high-power units
- studies for Level 1, Level 2 and Level 3 PSAs

Gentilly-2

Gentilly-2 does not currently have a full PSA. Various probabilistic studies were done as part of the original design verification (known as safety design matrices), and reliability models have been developed for various systems important to safety. Hydro-Québec no longer requires a PSA for Gentilly-2 because it is being defuelled, leading to eventual decommissioning. However, Hydro-Québec has conducted a reliability assessment for its provisions to safely cool the fuel in the irradiated fuel bay.

Point Lepreau

In previous reporting periods, Point Lepreau developed methodologies for PSA Level 1 and Level 2, internal events, internal flood, internal fire and seismic events. The methodologies covered at-power and shutdown operating states. A Level 2 PSA for Point Lepreau was completed in 2008.

Point Lepreau also performed a PSA-based seismic margin assessment, using an earthquake with an approximately 10,000-year recurrence interval.

During the reporting period, Point Lepreau updated its PSAs to conform to S-294. Seismic and external flooding events are among the events assessed using modern-day methods. Seismically induced fires and internal flooding have also been included in the Level 2 PSA.

Annex 14 (i) (g)
Example of Assessment for Purpose of Integrated Safety Review for Life Extension

In 2010, OPG developed a continued operations plan to document the technical basis actions required to support the incremental life extension of the Pickering B units to the end of 2020. The plan integrates the improvements necessary to close issues identified in the EA and ISR for Pickering B and is updated annually. OPG used a draft revision of the CNSC regulatory document *Life Extension of Nuclear Power Plants* (RD-360) to systematically identify activities (i.e., analyses, upgrades, studies or modifications) required to provide the technical basis for continuing operation of Pickering B. Since 2011, OPG has completed more than half of the activities identified in the Pickering B continued operations plan, with the remaining actions scheduled for completion prior to entering into the incremental life extension time frame.

In 2012, OPG completed the technical analysis to support the life extension of Pickering B. The life-limiting components of the Pickering B units are the pressure tubes, which have an assumed design life of 210,000 effective full-power hours. The assessment demonstrated that the pressure tube effective life can be extended to 247,000 effective full-power hours. Based on that assessment, the pressure tubes are predicted to reach the end of their assumed design life in approximately 2015.

In 2011, OPG developed a sustainable operations plan for Pickering B (as well as Pickering A) that documents strategies, direction and actions to address the unique challenges, constraints and risks associated with approaching the end of commercial operation. The sustainable operations plan, which is also updated annually, describes the arrangements and activities required to demonstrate that safe and reliable operation of Pickering will be maintained and sustained, for each of the 14 CNSC safety and control areas for the period of operation up to the permanent shutdown of each reactor. For the majority of safety and control areas, no changes are anticipated from a program perspective. The changes and plans deal primarily with people-related issues and business issues pertaining to the life expectancy of the NPP. The sustainable operations plan also contains some preliminary information about the first stages of decommissioning.

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

The CNSC regulatory document *Aging Management for Nuclear Power Plants* (RD-334) establishes regulatory expectations for integrated and component-specific aging management programs in NPPs. The CNSC will begin adding this document to the existing licences to operate as they are renewed in the next reporting period. In anticipation of this, NPP licensees have developed integrated aging management programs consistent with industry best practices.

Prior to the development of RD-334, Canadian licensees had developed a series of component or degradation mechanism-specific aging management programs to address known aging mechanisms. The most significant programs are described below. These plans adopt minimum inspection and testing requirements that are found in the following CSA standards, which are cited in the licences to operate:

- *Periodic Inspection of CANDU Nuclear Power Plant Components* (N285.4)
- *Periodic Inspection of CANDU Nuclear Power Plant Containment Components* (N285.5)
- *In-Service Examination and Testing Requirements for Concrete Containment Structures for CANDU Nuclear Power Plant* (N287.7)

These standards stipulate minimum periodic inspection and testing program requirements for nuclear pressure boundary components, containment components and containment structures. Minimum inspection and testing program requirements are expanded, as required, to address operational and safety issues.

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. The document describes the strategy to manage heat transport system materials and identifies specific component sub-programs and the key interfaces between various NPP programs and processes.

Feeder Pipe Lifecycle Management Plan

This plan establishes the inspection and maintenance strategy to mitigate risks related to feeder aging and degradation mechanisms. Specific program inspection and maintenance activities are described to mitigate degradation caused by bend thinning, bend cracking, occurrence of localized flaws adjacent to welds and weld cracking. This plan also documents the strategy for determining the need for feeder replacement.

Fuel Channel Lifecycle Management Plan

The plan presents the strategies established to ensure the effects of fuel channel aging are monitored and managed effectively. It also discusses degradation mechanisms, including dimensional changes due to service conditions (axial and diametral expansion, wall thinning and tube sag), deuterium uptake, fracture toughness changes, pressure tube to calandria tube contact and the potential for blister growth, as well as re-fuelling-related service-induced damage to inside surfaces. Research results from the Fuel Channel Life Management Project guide inspection plans to monitor fuel channel fitness for service for the intended operational life. This project is being used to confirm the safety of ongoing operation of the NPPs as they approach their anticipated end of life, since fuel channels are typically the major life-limiting component in the CANDU design.

Flow-accelerated Corrosion Program

This program identifies susceptible systems and monitors and manages degradation related to flow-accelerated corrosion and other degradation mechanisms (such as erosion), mainly in secondary side (non-nuclear) and certain primary side (nuclear) piping systems. The program is based on the EPRI program and uses the CHECWORKS software as a guide to identifying and selecting inspection locations and processing measured data to determine thinning rates and acceptability for continued service. For piping that cannot be modelled using CHECWORKS, due to geometrical constraints or thinning mechanism (such as small-bore piping or thinning due to an erosive mechanism), manual calculations are used to evaluate the thinning rate and acceptability for continued service.

Steam Generator Lifecycle Management Plan

This plan establishes the inspection and maintenance strategy to control 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, internal tube blasting, blow-down practices during operation and occasional chemical cleaning).

Containment

Requirements for the design, construction, commissioning and in-service inspection of the concrete containment structures are contained in CSA N287.7. Licensees perform periodic in-service inspection and testing of the containment 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 N285.5.

Component replacement

The Canadian nuclear industry continues to take initiatives to prevent and manage problems related to acquiring replacements for equipment that is no longer available from the original manufacturer. COG has an Emergency Spares Assistance Process to obtain spare parts from other utilities to meet the needs of CANDU NPPs. As well, a number of replacement components (including gaseous fission product detectors, 48 volt indicating fuses, D_2O leak detection system, potentiometers and shut-off rod motors) were acquired through COG on behalf of several CANDU NPPs. The Canadian industry also has developed some capability, within an appropriate QA program, to reverse-engineer and manufacture replacement parts that are no longer available.

Annex 15 (a)
Detailed Requirements and Guidance for Control of Radiation Exposure of Workers and the Public

The CNSC *Radiation Protection Regulations* incorporate 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 regulations address the following:

- implementation and requirements of licensee radiation protection programs
- the requirements for ascertaining and recording of doses
- the definition of action level and the actions to be taken when an action level has been reached
- the requirement to inform workers of the risks associated with radiation to which the worker may be exposed and of effective and equivalent dose limits
- the requirement for when to use licensed dosimetry services to ascertain dose
- effective and equivalent dose limits for nuclear energy workers, pregnant nuclear energy workers and persons who are not nuclear energy workers
- dose limits that apply during the control of emergencies
- actions to be taken when a dose limit is exceeded and the process of authorizing the return to work
- requirements for licensed dosimetry services
- requirements for labelling of containers and devices
- requirements for posting of radiation warning signs

The CNSC has developed a number of regulatory documents to assist licensees in matters related to radiation protection and environmental protection. CNSC regulatory guide *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 the ALARA principle through a licensee's organization and management of radiation protection, provision of dedicated resources, training, establishment of action levels, documentation and other measures
- development of performance goals and 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.

Licensees must use a CNSC-licensed dosimetry service to measure and monitor radiation doses of nuclear energy workers who have a reasonable probability of receiving an effective dose greater than 5 mSv in a one-year dosimetry period. CNSC regulatory standard *Technical and Quality Assurance Requirements for Dosimetry Services* (S-106) contains accuracy, precision and quality assurance requirements for dosimetry services licensed by the CNSC. The requirements in S-106 meet, and in some instances exceed, 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). Licensed dosimetry services must file the dose results of each nuclear energy worker to the Canadian National Dose Registry, which is maintained by Health Canada.

Annex 15 (b)
Details Related to Doses at Nuclear Power Plants

Follow-up to the alpha event at Bruce A

In November 2009, during refurbishment work in the vault of Bruce A Unit 1, unforeseen alpha contamination risks resulted in unplanned personnel exposures. The incident was described in the fifth Canadian report, along with the initial follow-up.

In June 2010, pursuant to subsection 12(2) of the *General Nuclear Safety and Control Regulations*, the CNSC requested all NPP licensees to do the following:

- perform a risk identification and characterization survey with respect to the presence of alpha hazards in their NPPs
- implement work controls to mitigate potential alpha exposures for fuel-handling workers in their NPPs
- enhance radiation protection program requirements related to alpha monitoring and control, as deemed necessary (programmatic requirements must take current industry best practices and OPEX into account)

CNSC staff determined, through review and inspection, that the measures currently in place in each NPP are sufficient to protect workers from alpha hazards. The required enhancements to the licensees' radiation protection programs in 17 specific areas included improvements in documentation, work planning, instrumentation, workplace characterization, dosimetry, and others. The NPPs now have in place the measures necessary to consider alpha hazards in their work planning and execution, based on worldwide industry best practices. Verification of effective implementation of alpha monitoring and control programs has been integrated into the CNSC's routine regulatory oversight activities. Below are individual updates for the licensees.

Bruce Power

Bruce Power's follow-up included a confirmation of the doses attributed to the alpha event. The final collective dose assigned due to the uptake of alpha contamination by workers during the Unit 1 alpha event was 511.9 mSv. Of the 557 affected workers:

- 410 workers were assigned a dose of less than 1.0 mSv
- 104 workers were assigned a dose between 1.0–2.0 mSv
- 40 workers were assigned a dose between 2.0–5.0 mSv
- 3 workers were assigned a dose between 5.0–10 mSv
- 0 workers were assigned a dose greater than 10 mSv

Noting that the annual effective dose limit, per the *Radiation Protection Regulations*, is 50 mSv, CNSC staff concluded that no regulatory dose limits were exceeded as a result of the event.

In February 2010, an independent organization, the Radiation Safety Institute of Canada, was asked to provide independent and impartial assistance in regards to the alpha contamination event that occurred at Bruce A. This was primarily in response to a joint request from the Provincial Building and Construction Trades Council of Ontario, Bruce Power, Comstock Canada (representing the construction companies at Bruce A Restart) and AECL. A report was prepared with findings and recommended improvements to ensure the protection of workers.

This report is publicly available on the Bruce Power Web site (http://www.brucepower.com/wp-content/uploads/2011/10/RSIC-Final-Report.pdf).

With the co-operation of all parties, the Radiation Safety Institute provided support to the affected workers and to the management of Bruce Power. This was done through an extensive independent program of question-and-answer sessions for workers at Bruce A Restart, by establishing an independent HELPLINE for confidential assistance to workers and their families and by developing and delivering an education program for workers and construction company health and safety professionals on radiation exposure (including alpha radiation) and on the principles and practice of radiation safety. The outcome of these initiatives, which reached several hundred workers, included a lowering of the anxiety level of the affected workers and their families and an improved understanding by the workers of alpha radiation and radiation exposure in general, including radiation protection principles and practices. In addition to the assistance program, the Radiation Safety Institute of Canada was asked jointly by the parties to conduct an independent review of the exposure incident to assess the potential health effects for workers of the internal radiation dose received and to offer recommendations for improvement as required. Its scientific and technical review included a review of the circumstances that caused the internal exposure of the workers, a review of the radiation dose assessments carried out by Bruce Power and a comprehensive review of the scientific basis, methodology and rationale for the radiation doses finally assigned by Bruce Power to each exposed worker, as required by the regulations.

Notwithstanding that Bruce Power had already made a number of significant improvements for worker safety at Bruce A Restart in response to the contamination incident, the institute believed that further enhancements were required in the interests of worker safety, both for the present and the future. These were documented in the 19 recommendations in the Radiation Safety Institute report, which Bruce Power has now acted upon.

OPG, Hydro-Québec and NBPN

At the time of the request to all NPP licensees, OPG had already made several adjustments to its radiation protection program based on current industry best practices. OPG subsequently took further action to systematically review and enhance alpha monitoring at its facilities. Several enhancements were implemented, most notably in the areas of hazard awareness, instrumentation, work controls and the use of personal air samplers to support the alpha dosimetry program. In 2012, based on regulatory review and facility inspection, the CNSC confirmed that OPG’s program satisfactorily addresses all 17 aspects identified in the CNSC’s request. The CNSC concluded that the current alpha monitoring and control program meets regulatory expectations for the control and minimization of exposures due to alpha contaminants.

Long-term radiation protection program enhancements were implemented to monitor and control alpha hazards and to align Hydro-Québec’s and NBPN’s programs with industry best practices. Protective and control measures were implemented to protect workers from alpha radiation hazards.

Summary of doses to NPP workers during the reporting period

The CNSC *Radiation Protection Regulations* reflect the 1990 recommendations in ICRP 60. Workers at NPPs are restricted to dose limits of 50 mSv in a one-year dosimetry period 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 during the reporting period. 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 2010 to 2012

NPP	Year	# of reactors	Collective dose from routine operations (person-Sv)	Collective dose from outages (including forced outages) (person-Sv)	Total collective dose (person-Sv)	Maximum individual dose (mSv)
Bruce A and B	2010	6	0.799	5.46	6.26	25.18
	2011	6	1.039	9.41	10.45	25.16
	2012	6	0.645	12.12	12.76	29.00
Darlington	2010	4	0.331	3.37	3.70	15.74
	2011	4	0.333	1.33	1.67	11.47
	2012	4	0.292	1.50	1.79	11.70
Gentilly-2	2010	1	0.105	0.64	0.75	10.98
	2011	1	0.098	0.60	0.70	8.51
	2012	1	0.098	0.13	0.23	3.60
Pickering A and B	2010	6	1.08	5.92	7.01	13.47
	2011	6	0.84	5.25	6.09	16.34
	2012	6	0.86	7.57	8.42	19.60
Point Lepreau	2010	1	n/a	1.38	1.38	11.9
	2011	1	n/a	1.95	1.95	12.22
	2012	1	.008	0.94	0.95	5.10

The collective dose from routine operations shows n/a for Point Lepreau from 2010 and 2011 because it was in a state of refurbishment, and therefore no routine operations were carried out.

Total collective dose at all Canadian nuclear power plants from 2010 to 2012

Year	# of reactors	Collective dose (person-Sv)
2010	18	19.10
2011	18	20.86
2012	18	21.82

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 emissions) 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 2012. 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 were below 1 percent of the values authorized by the CNSC.

Gaseous emissions released from Canadian nuclear power plants (2010 to 2012)

	Tritium oxide (TBq)	Carbon-14 (TBq)	Noble gases (TBq-Mev)	Iodine-131 (TBq)	Particulates (TBq)
Bruce A					
DRL	1.35E+05	1.05E+03	4.75E+04	1.18E+00	3.10E-01
2010	6.40E+02	1.26E+00	7.97E+01	1.63E-05	9.29E-06
2011	6.00E+02	1.36E+00	6.68E+01	3.58E-05	7.06E-06
2012	4.50E+02	2.30E+00	6.82E+01	2.18E-04	7.45E-06
Bruce B					
DRL	2.71E+05	1.08E+03	1.06E+05	9.15E-01	7.42E-01
2010	9.12E+02	3.83E+00	3.18E+01	4.95E-05	6.51E-05
2011	7.17E+02	1.44E+00	3.64E+00	4.19E-05	5.07E-05
2012	3.26E+02	1.16E+00	3.64E+00	4.13E-05	1.80E-05
Darlington					
DRL, prior to 2012 Since April 2012	4.3E+04 5.9E+04	1.8E+03 3.5E+02	3.9E+04 4.5E+04	4.7E+00 1.4E+00	2.4E+00 6.7E-01
2010	1.43E+02	1.28E+00	1.82E+01	1.28E-04	7.45E-05
2011	1.40E+02	1.00E+00	2.20E+01	1.80E-04	4.00E-05
2012	1.3E+02	1.00E+00	1.90E+01	1.40E-04	3.40E-05
Gentilly-2					
DRL, prior to 2011 Since 2011	4.4E+05 8.58E+04	8.8E+02 1.99E+02	1.7E+05 7.70E+04	1.3E+00 3.25E-01	1.9E+00 1.21E+00
2010	1.69E+02	2.92E-01	1.23E-01	7.29E-07	1.54E-06
2011	1.90E+02	2.71E-01	1.16E-01	Not detected	9.13E-07
2012	2.13E+02	4.41E-01	3.87E-01	8.32E-06	1.79E-06
Pickering A					
DRL	5.5E+04	6.3E+03	2.9E+04	9.7E+00	2.1E+00
2010	2.80E+02	2.15E+00	1.51E+02	2.14E-05	5.25E-05
2011	2.12E+02	1.04E+00	9.92E+01	1.48E-05	8.18E-06
2012	2.56E+02	8.77E-01	1.05E+02	1.08E-05	4.51E-06
Pickering B					
DRL	5.5E+04	6.3E+03	2.9E+04	9.7E+00	2.1E+00
2010	2.89E+02	9.20E-01	7.78E+01	5.42E-06	2.87E-06
2011	3.40E+02	7.67E-01	8.33E+01	8.84E-06	3.60E-06
2012	2.79E+02	9.44E-01	1.90E+01	6.55E-06	3.56E-06
Point Lepreau					
DRL	4.30E+05	3.30E+03	7.30E+04	2.20E+01	5.40E+00
2010	1.40E+01	2.90E-02	Not detected	Not detected	1.50E-07
2011	4.50E+01	2.80E-02	Not detected	Not detected	Not detected
2012	1.40E+02	3.70E-02	Not detected	Not detected	Not detected

Liquid effluent released from Canadian nuclear power plants (2010 to 2012)

	Tritium oxide (TBq)	Gross beta-gamma (TBq)	Carbon-14 (TBq)
Bruce A			
DRL	2.13E+06	1.00E+02	2.61E+03
2010	2.13E+02	4.16E-03	7.62E-04
2011	2.95E+02	6.29E-04	1.70E-03
2012	1.40E+02	5.79E-04	5.37E-04
Bruce B			
DRL	2.27E+06	1.07E+02	2.78E+03
2010	4.87E+02	2.65E-03	2.54E-03
2011	5.10E+02	2.38E-03	2.82E-03
2012	1.14E+03	3.35E-03	4.63E-03
Darlington			
DRL, prior to 2012 Since 2012	4.3E+06 5.3E+06	7.1E+01 7.1E+01	9.7E+02 9.7E+02
2010	1.36E+02	2.80E-02	4.86E-04
2011	1.10E+02	3.10E-02	1.90E-03
2012	1.30E+02	3.00E-02	6.30E-04
Gentilly-2			
DRL, prior to 2011 Since 2011	1.20E+06 1.16E+07	5.30E+00 1.75E+02	1.00E+02 2.40E+03
2010	2.86E+02	4.01E-03	1.38E-02
2011	2.44E+02	5.35E-03	1.89E-02
2012	3.51E+02	1.09E-03	2.88E-02
Pickering A			
DRL	5.1E+05	4.7E+00	6.4E+01 Note 1
2010	1.02E+02	1.63E-02	n/a
2011	1.16E+02	4.07E-03	n/a
2012	1.10E+02	1.10E-02	n/a
Pickering B			
DRL	5.1E+05	4.7E+00	6.4E+01
2010	1.55E+02	1.72E-01	3.57E-03
2011	1.95E+02	1.37E-02	2.24E-03
2012	1.77E+02	1.92E-02	1.14E-02
Point Lepreau			
DRL	1.60E+07	1.50E+01	3.00E+02
2010	2.47E+01	1.48E-04	8.00E-05
2011	3.40E+01	8.20E-05	3.80E-05
2012	7.80E+02	7.20E-05	1.40E-02

Note 1: The carbon-14 releases in liquid effluent from Pickering A are reported in the carbon-14 liquid release data for Pickering B.

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 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 it interfaces with the Province of Ontario Nuclear Emergency Response Plan (PNERP; see annex 16.1(d)). 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 plan defines a station emergency as a sudden, unexpected occurrence of unusual radiological conditions with the potential for accidental exposure to staff or the public exceeding regulatory limits. A station emergency can also be declared for a non-radiological event requiring protection of onsite personnel and activation of Bruce Power's emergency response organization.

The emergency plan is consistent with the corresponding Bruce Power safety analysis and reports that were provided to the CNSC.

Security (or hostile action) response is addressed through separate provisions. However, the provisions regarding potential releases of radioactive materials also apply to security incidents (e.g., the need for offsite notification, situation updates, or confirmation of any radioactive releases). Emergency response related to transportation of nuclear substances is addressed by a separate plan.

To implement its emergency plan, Bruce Power has developed specific nuclear emergency preparedness and response arrangements. In the event of an onsite nuclear emergency at 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, staff would further categorize it according to criteria contained in the PNERP. To simplify this step, many events have been categorized according to the province of Ontario's notification designations.

Emergency drills and exercises are an integral part of Bruce Power's overall process of program assessment. These exercises are conducted periodically at Bruce Power's NPPs, in co-operation 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 might require the activation of the PNERP and the Province of Ontario’s joint emergency information centre, which is located in the Toronto offices of Emergency Management Ontario. Pending activation and operation of the centre, Bruce Power’s emergency response organization would, on an interim basis, communicate relevant information to the public and the media. With the emergency information centre in operation, the provincial government would assume control of information regarding the offsite response. The Municipality of Kincardine would establish a local emergency information centre at its offices. Bruce Power would assist the municipality of Kincardine with the preparation of information to the local public by ensuring accuracy. Emergency-related information prepared at the local and provincial emergency information centres would be jointly scrutinized for accuracy by all three parties prior to its release.

In response to Fukushima, Bruce Power is in the process of revising its emergency response organization and emergency plans to use an all-hazards approach utilizing incident management system concepts. Bruce Power has already upgraded its emergency management centre and conducted a proof of concept exercise (Huron Challenge IV), which is described in annex 16.1(f). Bruce Power plans additional validation drills and implementation of the new emergency response organization and emergency plan in 2013, during the next reporting period.

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 locations. It describes concepts, structures, roles and processes to implement and maintain an effective OPG response to radiological emergencies that could endanger onsite staff, the public or the environment. It provides a framework for interaction with external authorities and defines OPG commitments under the PNERP.

Similar to Bruce Power, the OPG Consolidated Nuclear Emergency Plan defines a station emergency as a sudden unexpected occurrence of unusual radiological conditions with the potential for accidental exposure to staff or the public exceeding regulatory limits. The OPG plan focuses on the release of radioactive materials from fixed facilities and on OPG interfaces with the PNERP (see annex 16.1(d)). 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 confirmation of any radioactive releases.

The emergency plan is consistent with the corresponding OPG nuclear safety analyses and reports provided to the CNSC.

To implement its nuclear emergency plan, OPG has developed site-specific nuclear emergency preparedness and response arrangements for its NPPs. In the event of an onsite nuclear emergency at an OPG NPP, OPG staff would immediately classify the nuclear emergency in accordance with criteria specified in emergency procedures. Should this emergency have offsite implications, OPG staff would further categorize it according to criteria contained in the PNERP. PNERP categorization criteria would be referenced in procedures to ensure alignment. Offsite notifications would be made following categorization, within required time limits.

Emergency drills and exercises are an integral part of OPG's overall process of program assessment. Exercises are conducted regularly at all OPG NPPs, in co-operation 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 audiences for OPG's nuclear emergency public information program are those who live or work near OPG NPPs. In the event of a nuclear emergency involving an OPG NPP, OPG emergency response procedures and agreements require 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 would depend upon the related circumstances. For events that are not severe enough to warrant activation of the PNERP but that might interest neighbours and other stakeholders, OPG would issue news releases or verbal briefings to the local media, with copies to provincial and municipal officials. Should the situation warrant it, OPG may activate its onsite or near-site local media centre for briefing or interview purposes.

More severe events may require activation of the PNERP and provincial and municipal emergency information centres. OPG may also communicate relevant information within its jurisdiction to the public and media.

Gentilly-2 nuclear emergency plan

The Hydro-Québec *Plan des mesures d'urgence* describes its arrangements to cope with actual or potential nuclear emergencies at Gentilly-2. 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 NPP
2. Station alert
    - dangerous or potentially dangerous situation within an important area of the NPP
3. Local alert
    - 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
    - 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 Quebec

The Gentilly-2 plant conducts emergency drills at least once per year. It also participates in externally organized drills in co-operation 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 relations 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 equipment
- tested emergency plans

Point Lepreau Emergency Plan

NBPN's Emergency Response Plan serves as the common basis of site-specific nuclear emergency preparedness and response arrangements at Point Lepreau. Emergency preparedness services follow a process defined within the 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 endanger the safety of onsite staff, the public or the environment. This process also includes the necessary coordination with external organizations required to support any emergency response. The types of emergencies covered include a sudden unexpected occurrence of unusual radiological conditions, with the potential for accidental exposure to staff or the public exceeding regulatory limits, fire, chemical, medical and natural disasters such as storms, floods and earthquakes. Security response to hostile actions is dealt with through separate provisions. However, the provisions regarding potential release of radioactive materials also apply to security incidents.

Emergency drills and exercises are an integral part of Point Lepreau's overall process of program assessment. Exercises are conducted periodically in co-operation with other organizations and jurisdictions that have a role in nuclear emergency preparedness and response.

The New Brunswick Emergency Measures Organization (NBEMO), an agency of the provincial government, is responsible for actions to protect the public. NBEMO 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. This includes the mass decontamination plan. This plan details the requisite monitoring and decontamination in the event a nuclear emergency requires the evacuation of local area residents.

Annex 16.1 (d)
Provincial Offsite Emergency Plans

Province of Ontario

The Province of Ontario possesses the greatest number of commercial power reactors (18 operating reactors) of any jurisdiction in Canada. In addition, a research reactor is located at Chalk River, and 6 U.S. nuclear facilities lie within 80 km of Ontario. 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 provincial *Emergency Management and Civil Protection Act* governs emergency preparedness and response in Ontario. This legislation requires the provincial government to formulate a plan for emergencies arising in connection with nuclear facilities. It also permits the province to designate municipalities that shall plan for nuclear emergencies. Emergency Management Ontario (EMO) administers the PNERP on behalf of the province 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 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, details the support and coordination of the activities of provincial ministries, nuclear facilities, the Government of Canada (including the CNSC) and designated municipalities in order to meet the objectives of the plan.

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 exercises focusing on nuclear or radiological emergencies are conducted regularly with the participation of the licensees and different levels of government.

In 2009, Emergency Management Ontario received provincial Cabinet approval to improve emergency management response capabilities for major nuclear facilities located in Ontario. To implement these major changes to the plans, EMO will be seeking assistance to develop a provincial strategy that will enable them to address these issues and concerns, such as extending public alerting and looking at the availability of potassium iodide to residents in the full 10-km primary zone.

Province of Quebec

Within the province of Quebec, under the *Civil Protection Act*, it is the municipalities that are responsible for emergency measures on their territory. In the event their capacity to respond is exceeded, or likely to be, the Ministère de la sécurité publique would coordinate responses and additional support of the Government of Quebec. It is to this end that the Organisation de la sécurité civile du Québec (OSCQ) was established. The 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 *Civil Protection Act*.

The PMUNE-G2 clearly defines the responsibilities of government departments and agencies in a nuclear emergency at Gentilly-2, with the objectives of minimizing the consequences, protecting the public and providing support to municipal authorities. In effect since 1983, the PMUNE-G2 is updated regularly. In 2002, response procedures and support programs were revised 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 Gentilly-2. 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 organizations in Quebec and to maintain a link with federal institutions. The regional response centre 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 January 2012, 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 Gentilly-2. A Web site for sharing information was established. Furthermore, the municipalities within the 8-km zone are installing an early population warning system. The province of Quebec has special detection and analysis equipment capable of characterizing the environment and the food chain. Emergency response participants requiring the equipment undergo relevant training and exercises for its use on an annual basis.

The PMUNE-G2 master plan was revised in December 2012. However, in light of the decision by the Quebec government to shut down and decommission Gentilly-2, certain measures are being revised to reflect the reduced residual risks.

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:

- New Brunswick Emergency Measures Organization (NBEMO), which is the provincial lead agency for emergency management and business continuity, including radiological-nuclear contingencies
- NB Security 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, in conjunction with the following enhancements to emergency preparedness in New Brunswick:

- 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 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
- developing a training and exercise strategy for major scenarios, including nuclear response, so that NBEMO is exercised annually, rather than every three years (as in the past)
- replacing the inventory of potassium iodide pills, updating demographic information for the emergency planning zone and improving communications systems linking the offsite emergency centre and the joint emergency operations centre

Under New Brunswick's *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, which directs, controls and coordinates provincial emergency operations and assists and supports municipalities as required. NBEMO has recently updated the committee's handbook, which includes all the tasks the different departments are responsible for when there is an event.

The Provincial Emergency Action Committee maintains two states of readiness. The standby state requires representatives of departments to be available (on call). An emergency state is a state requiring action from NBEMO and/or other departments. During an emergency state, departmental representatives are called to headquarters and briefed on the corresponding emergency.

The province is divided into six emergency measure organization regions. In each region, emergency management 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, regional emergency committees are formed to provide assistance to municipalities and the population 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 regional emergency committee. Regional emergency operations centres are located in government facilities.

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 should an incident at Point Lepreau create an offsite emergency. The Point Lepreau Offsite Emergency Plan has gone through an extensive rewrite. This was required as some of the departmental functions no longer reflected the actual capacities accurately.

Should it be necessary to alert the public to the occurrence of an offsite emergency, wardens would oversee designated areas to ensure residents were 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 would advise the public of the need for any protective actions. Arrangements are in place to help individuals who might require physical assistance should evacuation prove necessary.

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.

Following the return to service of Point Lepreau, NBEMO recently put together a five-year nuclear exercise program that will allow for regular exercises and training to take place. NBMO will conduct yearly reviews of the offsite plan.

Annex 16.1 (e)
Details of Federal Emergency Provisions

Detailed 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 the uncontrolled release of radioactive material or exposures to uncontrolled sources of radiation, which pose or could pose a threat to public health and safety, property and the environment.

The FNEP contains the following information:

- an outline 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

Five nuclear emergency event categories are defined in the FNEP according to the potential scope of impacts on Canada and Canadians:

- Category A: an emergency at an NPP in Canada
- Category B: an emergency at an NPP in the U.S. or Mexico
- Category C: an emergency involving a nuclear-powered vessel in Canada
- Category D: other serious radiological emergencies or potential threats in Canada that require a multi-departmental or multi-jurisdictional response
- Category E: a nuclear emergency occurring outside of North America

The scope of the FNEP excludes the following situations:

- emergencies that pose only a limited radiological threat over a localized area and that are not anticipated to exceed the capabilities of regulatory, local or provincial/territorial authorities to respond, including but not limited to the following:
    - events at licensed nuclear facilities with no radiological offsite impacts or involving only non-radiological hazards to the personnel at the facilities, the public or the environment
    - transportation accidents involving regulated quantities of radioactive material on Canadian lands or in Canadian territorial waters
- management and coordination of the Government of Canada's actions during the recovery phase

The occurrence of a radiological or nuclear emergency would lead to a sequence of response actions and technical support functions focused on managing the event, mitigating its effects and protecting the public and environment from actual or potential radiological impacts. The extent of coordinating arrangements described in the FNEP and of individual departments and agencies would depend on the nature, magnitude and location of the event, responsibilities within federal jurisdiction and the level of assistance requested. The federal government would conduct emergency operations within the federal mandate and would provide, in accordance with prior arrangements or at the request of a provincial government, national support services and resources coordinated through the National Emergency Response System and provisions of the FNEP or a provincial annex in the FNEP.

Under the FNEP, a multi-departmental technical assessment group would be convened to provide the federal-level technical assessment of the threat and risk associated with the radiological hazard, as well as associated protective action recommendations, as required, for mitigating the radiological consequences on health, safety, property and the environment. The technical assessment group might establish task teams or experts within its operations to undertake specific technical assessment functions, such as environmental-pathways modelling, radiological assessment or field-based monitoring and surveillance.

As the Fukushima and Chernobyl accidents demonstrated, a severe nuclear emergency at an 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 threat (e.g., from exposure to fallout) to Canadian residents, property or the environment. Consequently, Canada’s response under the FNEP to a nuclear emergency occurring outside North America would likely focus on the following:

- controlling food imported from areas near the accident
- assessing the impact on Canadians living or travelling near the accident site
- assessing the impact on Canada and informing the public
- coordinating responses or assistance to foreign jurisdictions and organizations, national or international

The potential severity of other serious radiological emergencies or potential threats, as defined in the FNEP, would depend on case-specific factors. For fixed facilities and materials in transit, appropriate responses to possible emergencies can be planned in some detail. In other situations, emergency planning can be complicated by such factors as the potential magnitude and diversity of the radiation threat, the location of the source of the radiation, any impacts on essential infrastructures and the speed at which related circumstances may evolve.

Once a nuclear emergency situation would be stabilized and immediate and other actions to protect public health and safety completed, emergency management of the radiological hazard would shift from the response phase to the recovery phase. The FNEP Senior Official in consultation with the Chair of the FNEP technical assessment group, the Federal Assistant Deputy Minister of the Emergency Management and Regional Operations Branch (Public Safety Canada) and the Federal Coordinating Officer would recommend the return of the FNEP to routine reporting level and stand-down of some or all components of FNEP not required for the transition to recovery. The Federal Assistant Deputy Minister Emergency Management Committee, in consultation with the Privy Council Office, would approve the transition to recovery and termination of the emergency.

Responsibility for recovery falls primarily within provincial/territorial jurisdiction. If federally assisted recovery actions were required, the responsibility for coordinating recovery operations would be assigned to a specific Minister of the Government of Canada by the Privy Council Office and the Prime Minister.

The FNEP identifies the following federal activities, or support for the provinces, that are recognized as being part of the recovery phase:

- development of a long-term recovery management plan, including reference levels on residual dose from long-term contamination and strategy for restoration of normal socio-economic activities, including international aspects
- monitoring of contaminated areas, assessment of potential doses to public and workers and assessment of medium- and long-term health hazards
- environmental decontamination and radioactive waste disposal operations
- maintenance of dose registries for emergency workers
- non-radiological recovery operations
- proactive and transparent public information and international communication related to all of the above activities

Provisions of the nuclear 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. The CNSC emergency management program is aligned well with the *Emergency Management Act* (EMA).

Since the CNSC's regulatory obligations extend to a wide range of circumstances, facilities, activities and materials, it must plan for its possible involvement in a similarly diverse range of emergency scenarios. The CNSC maintains an Emergency Operations Centre (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, but it can also rely on an emergency generator in the event of loss of the electricity grid. The CNSC has an alternate site for emergency staff to assemble, should its main headquarters 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 would 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, its regulations and the EMA. 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 U.S. 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 – which are described below:

- 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.
- Operations enter the activated mode 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 CNSC's involvement could range from exchanging ideas and information to coordinating plans, attending training programs, participating in exercises and responding to actual emergencies. The CNSC Emergency Response Plan provides corporate guidelines for employee involvement. Specifically, the CNSC Emergency Response Plan defines the CNSC staff members who would participate 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 co-operation 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.

Annex 16.1 (f)
Description of Major Emergency Exercises

The March 2012 full-scale emergency exercise (Intrepid) held by Point Lepreau and the provincial authority (New Brunswick Emergency Measures Organization) simulated a severe accident and mock evacuation of the surrounding communities. It was an opportunity to review the adequacy and appropriateness of the onsite and offsite emergency plans. Intrepid 2012 was the first large-scale evaluated exercise using the incident command system at Point Lepreau under the revised Provincial Nuclear Off-Site Emergency Plan (2012) and was the first large–scale, evaluated exercise since 2006. The Intrepid 2012 scenario simulated a severe accident that would have led to a planned radiological release. There was also a simulated proactive evacuation of the NPP and the community, requiring the deployment of offsite resources. The response required the activation of both onsite and offsite emergency response organizations, which included the Provincial Emergency Operations Center, RCMP, Horizon Health, Ambulance NB, the Red Cross and the CNSC Emergency Operations Center. Overall, Intrepid 2012 was a successful exercise that met all of the objectives. All players demonstrated the ability to implement the measures necessary to protect the public and NPP staff in the event of a severe accident. The key findings from the Intrepid exercise have been incorporated as high-priority items in NBEMO’s detailed emergency preparedness sustainability project plan.

CNSC staff from headquarters and the CNSC site office at Point Lepreau also participated in exercise Intrepid. The CNSC’s technical assessment and regulatory operations teams used the opportunity to practise their functions of analysis and assessment. This included plume modelling and the evaluation of the protective actions taken by the provincial authorities.

Bruce Power and Emergency Management Ontario staged a series of training sessions leading to a functional exercise in the fall of 2012 that involved a beyond-design-basis accident. This exercise was designed to test Ontario’s ability to respond to a major natural disaster for both the onsite and offsite components of emergency management. In conjunction with this, Bruce Power was relocating its emergency management centre and upgrading emergency response equipment. More than 50 agencies were involved in the week-long regional disaster exercise, Huron Challenge Trillium Resolve, organized by Bruce Power and led by Emergency Management Ontario. More than 40 scenarios were played out by roughly 1,000 participants in the region. Municipalities in Bruce, Huron, Grey and Wellington counties faced a wide variety of simulated disaster scenarios, and provincial teams with specialized equipment were deployed, including the Ontario Provincial Police Urban Search and Rescue; Chemical, Biological, Radiological and Nuclear Response Team; the Ministry of Health and Long-Term Care’s Emergency Medical Assistance Team; and federal organizations such as Health Canada and NRCan, as well as non-governmental organizations such as the Red Cross.

In the scenario, the Bruce Power site was hit with a series of challenges, the most severe being a tornado matching the strength of the one that struck 60 km south of the Bruce Power site at Goderich, Ontario in 2011. The exercise simulated that all power was lost and backup and emergency generators were knocked out at Bruce B (a highly unlikely occurrence). For the scenario, Bruce A lost grid power, but backup and emergency generators were available. However, emergency-mitigating equipment was deployed to test Bruce Power’s ability to respond to total loss-of-power events at both NPPs simultaneously. Trained emergency staff responded both on the ground and in Bruce Power’s new, state-of-the-art emergency management centre. The emergency management centre was staffed and operated around the clock for three days during the exercise. While Bruce Power emergency and protective services responded with pumper trucks and portable generators to both NPPs, operations staff aligned plant systems to accept the portable cooling water and power.

The scenarios faced by emergency responders were extremely realistic and challenging, as emergency responders encountered blocked roads that they had to clear to reach the NPPs. The emergency mitigating equipment was deployed and placed in service in under two hours. As at Fukushima, communications were disrupted, making it very difficult for operations and responders to communicate, while offsite communication with the public and government agencies was also challenged. Bruce Power developed a very robust communications infrastructure that will allow it to communicate both internally and externally when needed.

The exercise was a proof of concept in which Bruce Power demonstrated that all the enhancements put in place as a result of the Fukushima event actually worked to a very high level. Bruce Power proved its ability to respond to the most challenging emergency scenario that the creators of Huron Challenge Trillium Resolve could conceive.

Darlington, Gentilly-2 and Pickering are also planning multi-level emergency exercises between now and 2016. Various federal and provincial authorities are expected to participate. The exercise at Darlington in May 2014, titled Unified Response, will be a full-scale exercise to test the preparedness and integration of the nuclear response plans of OPG, municipal governments, the Province of Ontario, the federal government and non-governmental agencies. The U.S. Nuclear Regulatory Commission will also participate. At the federal level, the CNSC, Health Canada and Public Safety Canada are involved in the exercise design and planning.

In March 2013, two national nuclear emergency preparedness workshops were held in Ontario and New Brunswick, with the objective of ensuring a clear understanding of the various nuclear emergency plans and interfaces across multiple jurisdictions and of identifying current best practices, gaps and areas for improvements. As part of these workshops, a table-top exercise was conducted using two escalating scenarios involving an NPP: a planning-basis accident and a beyond-planning-basis accident. The discussion was aimed at identifying gaps and issues, especially as they pertain to the interfaces between jurisdictions and response capabilities. The findings are currently being assessed.

Annex 17
Site Evaluation for a New Nuclear Power Plant During the Reporting Period

In support of the application for a licence to prepare the site and the prerequisite environmental assessment (EA) during the reporting period, OPG had conducted a number of site evaluation studies in 2009 to demonstrate that the Darlington new-build site meets the Canadian regulatory requirements, in particular, as described in regulatory document *Site Evaluation for New Nuclear Power Plants* (RD-346) (see subsection D.3 of chapter I for background information). The evaluation studies addressed external naturally occurring hazards and external human-induced events, including the following:

- external human-induced events (including radiological releases from nuclear events at the existing multi-unit Darlington NPP)
- dispersion of radioactive materials in air and water
- seismic hazards
- meteorological hazards (such as tornadoes)
- flood hazards (coastal and riverine)
- geotechnical aspects
- additional threats to cooling water supply (such as bio-fouling)

These hazards were assessed in terms of risk to the new nuclear units and ultimately to the public and the environment. A multi-technology approach was used to envelope the range of reactor technologies that were under evaluation for the site. This involved the use of a bounding plant parameters envelope, similar to the U.S.-based approach, encompassing the reactor designs under consideration. The composite plant parameters bound the corresponding site characteristic values. Furthermore, in each of the hazard areas, it was determined that the risk was acceptably low or could be reduced to an acceptable level through design mitigation.

In assessing the potential effects of climate change, the Darlington new-build project used climate change predictions that were developed by Environment Canada, the International Panel on Climate Change, and NRCan. The studies referenced include historical information, as well as predictions of continuing future trends in the specific area being assessed (the Great Lakes Basin).

Additionally, to assess the impact of protective measures on the local population (e.g., in terms of temporary evacuation and long-term relocation), bounding source terms were derived, based on the safety goals. OPG selected a core radionuclide inventory from one of the reactor technologies considered. Baseline releases for each radioisotope were then determined, based on the release fractions associated with a selected accident scenario from the safety analysis of that reactor design (a severe accident involving damage to the reactor fuel that was a high contributor to the large release frequency). These baseline releases were then normalized, based on the safety goals (threshold release values) specified in CNSC regulatory document *Design of New Nuclear Power Plants* (RD-337) for small release frequency and large release frequency. The source terms are considered to be within the realm of beyond-design-basis accidents (whether caused by extreme external events leading to potential loss of site infrastructure or by low frequency internal events) and are characteristic of severe accidents. Using these source terms, public doses were calculated for various distances from the NPP over various time frames. The results show that the affected areas are well within the 10-km primary zone around the NPP for which detailed planning and preparedness for exposure control measures would be expected.

OPG's overall conclusion was that the site is suitable for a new NPP.

During the reporting period, the public review period and hearing by the Joint Review Panel for the EA and the OPG application for a licence to prepare the site concluded. The Joint Review Panel consisted of three persons appointed by the federal Minister of the Environment and the Governor in Council (Cabinet), in consultation with the President of the CNSC. In addition to the Joint Review Panel chair, who was a member of the Commission, the remaining panel members were also appointed as temporary members of the Commission for the purpose of issuing the licence to prepare the site upon the successful completion of the EA.

During the reporting period, CNSC staff reviewed OPG's EIS submissions in support of the EA, as well as the licensing submissions in support of the licence to prepare the site. CNSC staff advised the Joint Review Panel prior to the hearing that staff had determined that:

- 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 the 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

Following the hearing process, the Joint Review Panel concluded in 2011 that the project was not likely to result in significant adverse effects. Following the Government of Canada's acceptance of the EA, the Joint Review Panel issued the licence to prepare the site in 2012. The Joint Review Panel report had 63 recommendations.

In particular, the Joint Review Panel recommended that the CNSC require OPG to undertake a quantitative cost-benefit analysis for cooling tower and once-through condenser cooling water systems, applying the principle of best available technology economically achievable.

OPG completed an analysis comparing once-through cooling with mechanical draft cooling towers and selected once-through cooling for the proposed NPP. OPG also conducted a public consultation and information program in conjunction with this assessment, as described in annex 9(c).

At the request of OPG, CNSC staff reviewed the analysis and concluded that the methodology used by OPG satisfies the Joint Review Panel recommendation. In addition, CNSC staff consider that there are no fundamental barriers to licensing a once-through cooling water system for the proposed NPP, subject to certain conditions communicated formally by CNSC staff to OPG.

CNSC staff's review does not bind future decisions by the Commission, should OPG submit an application for a licence to construct the NPP. CNSC staff will inform the Commission of their review and assessment in the next reporting period.

Annex 17 (ii) (a)
Environmental Assessment Process

The *Canadian Environmental Assessment Act* (CEAA, 2012), which replaced the CEAA 1992, came into force on July 6, 2012 and is the legal basis for the federal EA process in Canada. EAs identify whether a specific project is likely to cause significant environmental effects and determine whether those effects can be mitigated. By considering environmental effects and mitigation early in project planning, potential delays and unnecessary costs can be avoided or reduced.

The CNSC is the sole federal responsible authority for conducting an EA for nuclear-related designated projects identified in the *Regulations Designating Physical Activities* (the Project List). The federal Minister of the Environment may also designate a project not identified in the Project List if the project might cause adverse environmental effects or if there are public concerns related to those effects.

CNSC staff review the licence application and project description to determine if an EA is required. If an EA is required, the CNSC cannot issue a licence, grant an approval or take any other action to enable a project to be carried out, in whole or in part, until the EA process is complete and the decision issued.

A project may also trigger EAs by other jurisdictions. Where applicable, the CNSC and other jurisdictions determine if all the EA requirements can be addressed through a single process to reduce duplication and provide regulatory efficiency. Existing agreements provide guidelines for the roles and responsibilities of each jurisdiction in the assessment of such projects. Although the CNSC is the sole federal responsible authority for nuclear-related projects on the Project List, other federal departments may be requested to provide their technical expertise during the EA process. The CNSC may also delegate to another jurisdiction the conduct of an EA or any part thereof. In such cases, the CNSC remains legally responsible for ensuring that the applicable CEAA requirements are met, and the EA decision is rendered by the Commission.

The CEAA (2012) provides opportunities for public participation throughout the EA process. CNSC staff use a criteria-based approach to determine the timing and nature of Aboriginal and public participation opportunities (e.g., review of documents, meetings, open houses).

The Commission must render an EA decision in accordance with section 52 of the CEAA before a regulatory licensing decision can be made to allow the project to proceed. Should the Commission determine that a designated project is not likely to cause significant adverse environmental effects, it must establish through the licensing process any mitigation measures that must be undertaken by the proponent of the proposed project. In cases where the Commission concludes that a project is likely to cause significant adverse environmental effects, it must refer to the Governor in Council the matter of whether those effects are justified in the circumstances (in accordance with section 52(2) of the CEAA).

The CNSC licensing process involves the review and approval of the information for each project activity to be completed. This process ensures that project activities are within the bounds of the EA prior to their commencement. Furthermore, once work has begun, the CNSC licence and compliance process is used to verify the implementation of all required mitigation measures, to ensure the accuracy of the EA conclusions and effectiveness of mitigation, as appropriate.

Annex 17 (iii) (a)
Examples of Assessment and Measures Taken by Licensees to Re-evaluate and Address Site-related Factors

Assessment of climate change example – Bruce A and B

The two most likely impacts of climate change on NPPs are an increased frequency and intensity 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 potential effects of extreme weather have been considered in their design and the facilities have been constructed to withstand the effects of such events. Increases in the frequency and intensity of severe weather events that could potentially be related to climate change should have no effect on the NPPs over their operating life.

In a changing 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, it is predicted that average water level in Lake Huron is likely to drop by less than two metres in the next hundred years. The change is expected to be gradual, and no expected adverse impact on Bruce A and B is expected over the course of their operating lives.

Fish impingement and entrainment example – Pickering

To reduce fish impingement and entrainment at Pickering, a seasonal barrier net was installed around the intake on Lake Ontario in 2009. The net is removed from mid-November to mid-April due to icing conditions, rough winter lake conditions and unsafe conditions for divers to conduct routine maintenance of the net (about three times per week). The CNSC has set an impingement reduction target of at least 80 percent and an entrainment reduction target of at least 60 percent. The barrier net has achieved the impingement performance targets.

To offset entrainment and any residual impacts, CNSC staff and the Canadian Department of Fisheries and Oceans have concurred with OPG’s plan to proceed with support of an Atlantic salmon restoration project and restoration of a local wetland to offset the entrainment impacts and impingement during the winter when the net is not in place.

Annex 18
Supporting Details Related to CNSC Design Requirements and Design Assessments

Design requirements in CNSC regulatory document RD-337

The CNSC regulatory document *Design of New Nuclear Power Plants* (RD-337) sets out technology-neutral expectations (to the extent practicable) for the design of new, water-cooled NPPs. RD-337 includes direction concerning the following:

- establishing safety goals and objectives for the design
- utilizing safety principles in the design
- applying safety management principles
- designing structures, systems and components (SSCs)
- interfacing engineering aspects, NPP features, facility layout
- integrating safety assessments into the design process

RD-337 describes five levels of defence in depth:

- prevent deviation from normal operation and prevent failures of SSCs
- detect and intercept deviations from normal operation to prevent anticipated operational occurrences from escalating to accident conditions and to return the NPP to a state of normal operation
- minimize accident consequences by providing inherent safety features, fail-safe design, additional equipment, and mitigating procedures
- ensure that radioactive releases from severe accidents are kept as low as practicable
- mitigate the radiological consequences of potential releases of radioactive materials during accident conditions

In general terms, the dose acceptance criteria in RD-337 follow from the postulate that the risks due to a new technology should not be significant contributors to the already existing societal risks. The dose acceptance criteria must also be sufficient to ensure that very few accidents will require protective measures. The safety goal for large-release frequency is expressed in terms of the release of cesium-137 that would require long-term relocation of the population to mitigate the potential health effects. The safety goal for small-release frequency is expressed in terms of the release of iodine-131 that would require temporary evacuation to mitigate health effects. To achieve a balance between prevention and mitigation, a third goal is defined to limit the frequency of severe core damage. This ensures that the designer does not place too much reliance on the reactor containment.

RD-337 stipulates that SSCs important to safety are of proven design and are designed according to appropriate modern standards. Where a new SSC design, feature or engineering practice is introduced, adequate safety is proven by a combination of supporting R&D programs and by examination of relevant experience from similar applications. A qualification program is established to verify that the new design meets all applicable safety expectations. New designs are tested before entering service and are then monitored in service to verify that the expected behaviour is achieved. RD-337 also stipulates that the NPP design draws on OPEX in the nuclear industry and on relevant research programs.

RD-337 also contains requirements related to reliability, operability and human factors as they relate to design.

The requirement in RD-337 to design for reliability includes consideration of common-cause failures and allowances for equipment outages. There are design requirements related to single failure criteria for safety groups and fail-safe designs for SSCs important to safety. There are also special considerations for shared instrumentation for safety systems and the sharing of SSCs between reactors.

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 the 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.

RD-337 requires a human factors engineering (HFE) program that facilitates the interface between the operating personnel and the NPP by utilizing proven, systematic analysis techniques to address human factors. The program shall promote attention to plant layout and procedures, maintenance, inspection, training and the application of ergonomic principles to the design of working areas and environments. The NPP design must facilitate diagnosis, operator intervention and management of the NPP 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 HFE 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

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.

RD-337 also stipulates that the human–machine interfaces in the main control room, the secondary control room, the emergency support centre and the plant provide operators with necessary and appropriate information in a usable format that is compatible with the necessary decision and action times. Design requirements are established for both the main control room and emergency support centre to provide a suitable environment for workers under all possible conditions, taking ergonomic factors into account.

Vendor pre-project design review

The CNSC process for vendor pre-project design review 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 Web site.

Phase 1: The CNSC confirms that the submissions for the specific design demonstrate that the vendor understands Canadian regulatory requirements and expectations. The scope of submissions is fixed by the CNSC.

Phase 2: The CNSC confirms that the submissions for the specific design demonstrate that the proposed design is compliant with RD-337 and related documents. The scope of the review is fixed by the CNSC and usually involves assessment in 16 specific topical areas:

- defence in depth, SSC classification, dose acceptance criteria
- reactor core nuclear design
- means of shutdown
- fuel design
- emergency core coolant and emergency feedwater systems
- reactor control system
- containment
- pressure boundary of the primary heat transport system
- severe accident prevention and mitigation
- fire protection
- radiation protection
- QA program
- human factors
- out-of-core criticality
- robustness, safeguards and security
- safety analysis

Phase 3: Based on feedback received from the CNSC in phase 2, the vendor may discuss, in more depth, resolution paths for any design issues identified in phase 2. The scope of submissions is fixed by the vendor.

The review does not include non-technical considerations such as the following:

- 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 the time of this report, the following activities had been completed related to vendor pre-project design reviews:

- The phase 3 review was completed for Candu Energy ACR-1000.
- The Westinghouse AP1000 phase 2 review is scheduled to be completed in June 2013.
- The phase 1 and 2 reviews of AECL Enhanced CANDU 600 (EC6) were completed. Phase 3 is scheduled to be completed in June 2013.
- The AREVA EPR phase 1 review was cancelled at the end of 2012.

Annex 18 (i)
Details Related to Assessing and Improving Defence in Depth

The refurbishment of Bruce Units 1 and 2 and Point Lepreau for life extension was completed during the reporting period. Much of the major refurbishment work had been completed during the previous reporting period, such as replacement of steam generators, feeder pipes, calandria tubes and fuel channels, as well as major work on turbine generators and condensers. In addition to these major retube activities, various upgrades were completed that improved safety. They are described below for each project.

Safety improvements during refurbishment of Point Lepreau

During the reporting period, NBPN completed the following major work items:

- various inspections, cleaning and calandria tube installation
- upper feeder installation

In addition to the retube activities, NBPN also completed upgrades that improved safety (some were completed in the previous reporting period):

- the addition of supplementary shutdown system trip parameters and adjustments to some trip set points to improve shutdown system trip coverage
- installation of a third Class III electrical power standby diesel generator to support long-term generator maintenance
- installation of a dedicated high-efficiency particulate arrestor (HEPA) filter for the main control room to extend habitability during accident conditions
- installation of 19 passive autocatalytic hydrogen recombiners (PARs)[10] 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 helped to address safety issues identified by the Point Lepreau Level 2 PSA:

- installation of PARs (described above)
- procurement of spare parts for auxiliary boiler feedwater pumps
- addition of a fourth recirculating cooling water pump
- addition of a heat transport pump trip on high, upper-thrust bearing temperature
- improvements to numerous fire systems to support detection and suppression in key areas (e.g., reactor, turbine and service buildings) and egress in the turbine building, and provisions for enhanced fire testing
- installation of a dyke to retain oil at the heat transport pump troughs in the event of an oil fire

The following installations and design changes, also identified through the PSA, specifically addressed conditions during severe accidents:

- containment emergency filtered venting system

[10] PARs are devices intended to passively (without the need of external power) remove hydrogen from the containment atmosphere.

- calandria vault makeup system that provides for long-term cooling of calandria vessel (keeps calandria vessel intact, thereby preventing progression of the core debris to the vault and avoiding corium-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.

Safety improvements during refurbishment of Bruce Units 1 and 2

The major work items undertaken for the refurbishment of Bruce Units 1 and 2 include the following (some work having been carried out during the previous reporting period):

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

In addition to the fuel channel and steam generator replacement activities, there were a number of upgrades required to bring the units up to modern standards. The following upgrades were completed that also improve safety:

- addition of more shutdown system trip parameters and adjustments to some trip set points to improve shutdown system trip coverage
- installation of enhancements of shutdown system #2 related to neutron-overpower, including a significant increase in the number of flux detectors
- installation of a connection to the qualified power supply diesel generators
- environmental qualification of critical systems
- installation of four PARs within the reactor vault to assist in hydrogen mitigation in the event of a loss of coolant accident in which emergency core cooling is not available
- replacement of polychlorinated biphenyl (PCB) transformers
- seismic upgrades

The following design changes, which were implemented during the refurbishment, helped to address safety issues identified by the Bruce A PSA:

- installation of additional hydrogen igniters and PARs (described above)
- installation of a connection between emergency boiler cooling and the maintenance cooling system to provide a backup heat sink
- upgrade to the power house emergency venting system
- implementation of numerous fire system improvements

The following design change was identified through the Level 2 PSA specifically to address conditions during severe accidents:

- installation of an emergency moderator makeup system to provide for long-term cooling of the calandria vessel (keeps calandria vessel intact in accident sequences, thereby preventing progression of the core debris to the vault and avoiding corium-concrete interaction)

Several programmatic upgrades were also implemented, such as the following:

- severe accident management guidelines (SAMGs)
- a safe operating envelope (SOE) program
- an enhanced aging management program

Safety improvements for incremental life extension of Pickering B

During the reporting period, OPG completed the following activities in support of incremental life extension of Pickering B:

- installation of PARs
- deployment of emergency mitigating equipment
- implementation of SAMGs

Assessment of defence in depth in response to Fukushima

The designs of Canada's NPPs (all CANDU reactors) include several features that prevent accidents and can help mitigate impacts should an accident occur. The steam generators can provide sufficient cooling to prevent fuel damage (i.e., cooling is sufficient to enable returning the fuel to service). In the event the steam generators are unavailable, the large inventory of cool water (moderator and the calandria vault/shield tank) that surrounds the fuel can provide passive cooling to prevent accident progression and provide adequate time for long-term mitigation of accidents. CANDUs have two groups of independent, physically separated and diverse backup power and cooling water systems. In all, adequate time would be available for long-term mitigation of a beyond-design-basis accident. This conclusion also applies to the irradiated fuel bays, which have been assessed to be seismically robust with diverse means available for adding water.

Reassessment of protection against external hazards had already occurred for some of the NPPs that had been subject to ISRs for refurbishment projects – especially for seismic hazards, but also for other external hazards, including floods and high winds. The assessment is described in subsection 17(iii). Where vulnerabilities were identified, modifications were performed where warranted, such that refurbished plants approach or exceed modern standards.

As stated in subsection 14(i)(a), the CNSC Fukushima Task Force confirmed the licensees' assessments that adequate equipment and operating procedures are in place at all CANDU reactors to ensure that the key safety functions are carried out for extended durations and to bring the reactor to a safe, stable state following an accident. Although the risk of an accident is very low, NPP operators are implementing several modifications to improve their NPPs' ability to withstand severe external events and other challenges, such as a prolonged loss of power or the loss of all heat sinks. Following from NBPN's review of vulnerabilities after Fukushima, Point Lepreau is installing flood protection for its secondary control area tunnel, which will improve habitability during and after extreme external events. Darlington and Pickering A installed and are installing, respectively, additional flood barriers to provide additional margin for standby and emergency power generators.

In addition to addressing specific external hazards, Canada's response to Fukushima addressed the need for enhancements to defence in depth in various areas. The CNSC Fukushima Task

Force recommended that the licensees should systematically verify the effectiveness of, and supplement where appropriate, the existing NPP capabilities in beyond-design-basis accident and severe accident conditions, including the following:

- makeup capabilities for the steam generators, primary heat transport system and connected systems, moderator, shield tank and irradiated fuel bays
- overpressure protection of the main systems and components
- control capabilities for hydrogen and other combustible gases
- containment performance to prevent unfiltered releases of radioactive products
- design requirements for the self-sufficiency of a site, such as availability and survivability of equipment and instrumentation following a sustained loss of power and capacity to remove heat from a reactor
- control facilities for personnel involved in accident management
- emergency mitigating equipment and resources that could be stored onsite (separate from the protected area) or stored offsite and brought onsite if needed

The licensees are verifying and enhancing the above capabilities, as described below.

The licensees are evaluating means to provide additional coolant makeup from alternate sources. Some modifications are already in progress. At some NPPs, additional equipment has been procured and procedures have been implemented for its deployment. The licensees are also evaluating, or have already evaluated, the structural response of the irradiated fuel bay to seismic events and elevated temperatures (up to boiling). The licensees are continuing to evaluate potential enhancements to improve makeup capacity to the irradiated fuel bay.

To address the topic of overpressure protection of the main systems and components, the licensees demonstrated that the installed relief valves on the bleed condenser provide sufficient relief capacity and that pressure boundary failure due to overpressure will not occur. Licensees are still assessing existing margins-to-failure and investigating potential design changes for shield tank/calandria vault pressure relief.

All Canadian NPPs have either installed PARs (e.g., as part of refurbishment projects) or are in the process of installation and, in some cases, have accelerated the installation. NPP licensees provided or are providing confirmatory assessments demonstrating adequacy of PARs for severe accidents, and have either assessed or are assessing the need for PARs in the irradiated fuel bay areas, based on the assessment mentioned above.

In the area of containment venting, licensees other than Point Lepreau are evaluating the means to prevent the failure of the containment systems and, to the extent practicable, unfiltered releases of radioactive products in beyond-design-basis accidents, including severe accidents. The options being considered include emergency filtered containment vents.

In terms of monitoring and instrumentation, NPP licensees have established, or will soon establish, special measures to obtain information on which to base recovery actions for that period when batteries have become exhausted but portable diesel-powered generators have not yet been installed. The licensees are continuing to explore options to extend the duration of power supplies to instrumentation and control equipment. Licensees are installing, or evaluating the installation of, generators to provide backup power for instrumentation, as well as additional battery-powered instrument readout devices. The licensees are demonstrating that the equipment and instrumentation necessary for SAM and essential to the execution of SAMG will perform their function in the severe accident environment for the duration for which they are needed.

The licensees are evaluating the habitability of control facilities under conditions arising from beyond-design-basis and severe accidents.

The licensees are also assessing options for water and temperature monitoring from a safe location in the case of a loss of inventory. They are taking further action to procure emergency equipment (e.g., power supplies, pumps) that could be stored onsite or offsite and used to provide backup services during a beyond-design-basis accident (see subsection 16.1 (b) for further details).

Additional details on NPP design assessments and enhancements in response to Fukushima are provided in Canada's report to the Second Extraordinary Meeting.

Other safety improvements

The following are additional examples of design changes made during the reporting period at the NPPs. These changes were not associated with refurbishment projects or the response to Fukushima, but are examples of enhancements to defence in depth that are routinely made (e.g., during maintenance outages). They address requirements for design-basis accidents, as well as conditions predicted for beyond-design-basis accidents and severe accidents:

- OPG has modified the 37-element fuel bundle design to improve safety margins for certain anticipated operational occurrences and design-basis accidents at Darlington. This minor design change was achieved by reducing the diameter of the centre fuel element and hence creating more coolant flow area in the vicinity where dry-out first occurs. This re-optimization resulted in heat transfer performance improvement and delayed dryout, without adverse impact on online fuelling systems.
- Licensees are upgrading fire protection detection and suppression systems, such as through the following:
    - turbine fire suppression upgrades
    - fire detection system upgrade
    - public address system upgrades
    - protection of fire-safe shutdown cabling with fire wrap or fire-rated barriers
    - fire separation upgrades
    - fire separation upgrades to secondary control areas
    - installation of air-aspirating smoke detection systems
    - transformer deluge suppression upgrades
    - dyking construction (to contain large oil spills)
    - staging of additional manual fire fighting equipment in the station

In addition, a seasonal barrier net was installed around the Pickering intake on Lake Ontario in 2010 to reduce impingement and entrainment (see annex 17(iii)(a) for more details).

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 to CANDU is the research, development and implementation of passive autocatalytic hydrogen recombiners (PARs) 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 PARs. 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 and led to a technical basis for implementation of PARs 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 NPPs to determine the number and location of units in containment. PARs have now been installed, or are being installed, at other Canadian NPPs to address the potential hydrogen safety issue.

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 do not attempt to follow all aspects of a licensee's commissioning program. Rather, reliance is placed on the licensee's internal review process, which is mandated by the commissioning QA plan. 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

In some cases, partial tests are done if complete tests are not practical (as in the case of commissioning tests of emergency core cooling systems). For example, in the past, while commissioning tests were done 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.

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. CNSC staff can perform inspections, at any time, to confirm that procedural requirements are being complied with and that appropriate decisions are made.

Direct involvement of CNSC staff in commissioning concentrates on a few major tests, such as those that check the overall NPP response to specific events (e.g., a test of the NPP'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).

When reviewing commissioning, CNSC staff concentrate on these major tests because they are considered particularly important to safety. These tests check the overall performance of an NPP's safety features and can reveal problems that tests of individual components would not detect. CNSC staff also review test proposals, including 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 review 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 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.

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. This helps ensure that these tasks are not subsequently overlooked.

Typically, the licensee holds a series of commissioning completion assurance meetings to review the work done on particular systems. The CNSC staff at the site attend some of these meetings.

Annex 19 (iv)
Severe Accident Management Guidelines

In 2002, the Canadian NPP licensees formed a Severe Accident Management (SAM) working group, coordinated by COG, with the objective to formulate severe accident management guidelines (SAMGs) for CANDU reactors, based on international best practices. The emergency operating procedures at that time addressed a number of accident situations well beyond the 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 objective was to extend the scope of SAM 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 goal was 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, the 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 SAM for use in CANDU reactors, producing a set of generic guidelines applicable to all operating CANDU models and a more focused set of guidance documents for each of the CANDU models (CANDU-6, Pickering and Bruce/Darlington). COG extended the project to 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 project, also coordinated by a COG working group, dealt with the implementation of the project documents by the licensees, 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 SAM strategies during emergencies. Exercises to verify the effectiveness of the developed strategies and documentation have focused initially on potential core damage scenarios, identified by PSAs as constituting the highest residual risk. This implementation phase commenced in 2007, and all licensees have completed exercises and drills to test and validate their emergency organization response to SAMG events.

Following Fukushima and in response to the CNSC Action Plan, a joint project coordinated by COG was formed to examine the work necessary to extend SAMGs, based on lessons learned, and to provide additional support to the Canadian industry. The COG joint project has also been opened to interested international members who wish to take advantage of the work. The scope of the COG joint project includes the following:

- extension of SAMG programs to encompass the shutdown/low power states
- extension of SAMG programs to more fully consider multi-unit events
- development of SAMGs for irradiated fuel bay events
- development of a methodology for assessment of equipment and instrument survivability following severe accidents
- verification of strategies for maintaining containment integrity during severe accident conditions

- verification of strategies for in-vessel retention to prevent calandria failure and corium-concrete interaction
- development of a methodology for assessment of control facility habitability

Following completion of the above elements, individual licensees are expected to implement the findings or apply the methodologies and then take remedial actions, if necessary.

In addition to extension of the SAMG framework, Canadian licensees have been procuring portable diesel generators and portable water pumping capability (see annex 18(i)) to augment defence-in-depth capabilities should all AC power be lost and heat sink capability be compromised following an extreme external event. Deployment of this emergency mitigating equipment would be triggered from appropriate emergency operating procedures as a measure to prevent a severe accident and would also be incorporated into SAMG procedures to mitigate severe accident progression, if needed.

The following summarizes the progress of SAMG implementation 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 were initiated, with a validation exercise completed in 2009 at Bruce A and in 2010 at Bruce B. Bruce Power completed the implementation of a SAMG program for Bruce A and B for single-unit events. 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 implementation included a number of enabling procedures and minor design changes. Training of operations and emergency response crews is completed, and SAMG drills are performed on a periodic basis. Bruce Power is working in conjunction with OPG, through COG, on implementing multi-unit SAMG provisions. The COG project is defining the generic requirements for multi-unit response and updating the SAMG technical basis document using insight from the Fukushima event and recent analyses from various PSA studies. It is expected to be completed by the end of 2015.

Ontario Power Generation

OPG has undertaken a four-phase approach to SAMG implementation. Phase 1, or emergency response organization implementation, focused on developing NPP-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. SAMG drills specific to Darlington and Pickering were conducted at the OPG corporate emergency operations facility to verify the effectiveness of the developed strategies and documentation. Phase 1 implementation was completed by the end of 2010 and OPG has assembled a SAMG technical team to join the emergency response organization duty roster.

Phase 2, or NPP implementation, involved integration of SAMGs with the existing NPP emergency operating procedures, further development of enabling instructions and site-specific SAMG documents and training of operations staff. Phase 2 was completed for all OPG NPPs at the end of 2011.

Phase 3, or NPP implementation improvements, is currently underway to address improvements identified during phase 2. These include improving and validating the enabling instructions for field staff, ensuring SAMG strategies reflect the most current and accurate technical information, conducting training for emergency response organization and plant staff and including the use of emergency mitigating equipment in SAMG strategies (this equipment was procured post-Fukushima for use in the event of a station black-out). Additional training of field staff in the use of SAMG and enabling instructions are now underway (2013). Table-top drills have been completed for each OPG site, using the site-specific SAMG procedures, and onsite drills are planned for 2013, which will involve plant staff at site simulating activities to cope with a SAMG scenario. Phase 3 is expected to be completed by the end of 2013.

A fourth and final phase of SAMG improvements is planned for 2014–15. The focus of phase 4 will be to include multi-unit response in the SAMG strategies. OPG is working in conjunction with Bruce Power, through COG, on implementing multi-unit SAMG provisions.

Point Lepreau

Point Lepreau completed implementation of the SAMG program in late 2011, following extensive drills of the emergency response organization as a proof of concept that the SAMG procedures could be appropriately enacted should a severe accident occur. Further drills are being considered to more fully drill the operating staff on enabling instructions. The requirement for SAMG drills and ongoing training of the emergency response organization has been incorporated in the emergency preparedness program and included as part of an overall, five-year emergency exercise plan with offsite emergency response organizations.

Point Lepreau staff are actively participating in the COG joint project to extend and improve the current SAMG program. Further development of SAMG procedures, enabling instructions, training and drills will commence during the next reporting period. In addition, further assessments of equipment and instrumentation survivability and control room facility habitability will commence during the next reporting period.

A design guide for beyond-design-basis accidents has been developed and issued to assist with design modifications that will allow connection of emergency mitigating equipment to systems and provide a high degree of assurance that such measures will be effective during a severe accident. During the next reporting period following installation of the design modifications, operational procedures, SAMG procedures and other guidelines will be developed or modified as necessary. Training and drills will be performed to verify that the equipment can be deployed with high confidence within required time frames.

Gentilly-2

Gentilly-2 was shut down at the end of 2012, and no plans were made to further develop SAMG. However, Hydro-Québec is developing a specific program during the next reporting period for the irradiated fuel bay while the NPP proceeds towards safe storage state and eventual decommissioning.

Annex 19 (vii)
Programs to Collect and Analyze Information on Operating Experience

In Canada, programs to collect and analyze information on operating experience (OPEX) are established, the results are shared and the conclusions drawn are acted upon. Existing mechanisms are used to share important experience throughout the CANDU industry and with international bodies and other operating organizations and regulatory bodies.

OPEX feedback systems

The process of collecting, analyzing and disseminating lessons learned from information arising from 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, COG, AECL and other organizations.

Requirements and obligations

CSA document *Management System Requirements for Nuclear Power Plants* (CSA-N286-05), which is cited in all NPP operating licences, calls for measures to make sure that OPEX is documented, assessed and incorporated into the operation of the NPP and/or its QA programs, as appropriate. It also calls for sharing this information with personnel in the other phases of the NPP's lifecycle. The CNSC inspects NPPs and the licensee's corporate offices to ensure that the 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), which is cited in the licences to operate, are the primary sources 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 various aspects of NPP operations. These reports contain the CNSC inspection findings and the deficiencies that the licensees are required to correct.

International sources include the Incident Reporting System (IRS) of the IAEA/NEA and International Nuclear Event Scale 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 station condition records and OPEX from the World Association of Nuclear Operators (WANO), the Institute of Nuclear Power Operators and COG Web sites. Similar systems exist at other Canadian NPPs. AECL has implemented a similar system for its research reactor facilities at Chalk River.

COG also provides an information exchange program and chairs a weekly OPEX screening meeting teleconference that serves as a CANDU screening committee to review event reports from CANDU NPPs and nuclear industry sources for applicability and significance to other

CANDU NPPs. 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, the IAEA and the U.S. Nuclear Regulatory Commission. OPEX feedback from CANDU reactors in India and Pakistan comes through WANO participation in the COG OPEX screening meeting, as well as IAEA reports screened by COG.

The CNSC staff maintain a database to collect, follow up on, store and retrieve information from events. It includes records of events reported by the licensees, in accordance with CNSC regulatory standard S-99. The CNSC staff review and trend these events, in order to aid in the regulatory oversight of the NPPs.