Government of Canada Gouvernement du Canada

Canadian National Report for the Convention on Nuclear Safety

Fourth Report September 2007

Canada

Rapport national du Canada pour la Convention sur la sûreté nucléaire – Quatrième Rapport

Numéro de catalogue CC172-18/2007E-PDF
ISBN 978-0-662-46828-8

Publié par la Commission canadienne de sûreté nucléaire
Numéro de catalogue de la CCSN INFO-0763

Commission canadienne de sûreté nucléaire
280, rue Slater
Case postale 1046, Succursale B
Ottawa (Ontario) K1P 5S9
CANADA

Téléphone : (613) 995-5894 ou 1-800-668-5284
Télécopieur : (613) 995-5086
Courriel : info@cnsc-ccsn.gc.ca
Site Web : www.suretenucleaire.gc.ca

Canadian National Report for the Convention on Nuclear Safety

Fourth Report

September 2007

This report demonstrates how Canada has fulfilled its obligations under the *Convention on Nuclear Safety*. The report closely follows the guidelines regarding form and structure that were established by the contracting parties under Article 22 of the Convention.

This report was produced by the Canadian Nuclear Safety Commission on behalf of the Government of Canada. Contributions were made by representatives of Ontario Power Generation, Bruce Power, New Brunswick Power Nuclear, Hydro-Québec, Natural Resources Canada, Foreign Affairs and International Trade Canada, Atomic Energy of Canada Limited, the CANDU Owners Group, Public Safety Canada and the emergency response organizations of the provinces of Ontario, Québec and New Brunswick.

Canadian National Report on Nuclear Safety
Fourth Report

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

EXECUTIVE SUMMARY

This fourth Canadian report demonstrates how Canada continues to meet its obligations under the terms of the *Convention on Nuclear Safety* (the Convention), for the April 2004–March 2007 reporting period. During this reporting period, Canada effectively maintained — and in many cases enhanced — its measures to meet its obligations under the Convention. Enabled by a modern and robust legislative framework, these measures are implemented by a regulator and nuclear power plant (NPP) licensees that focus on the health and safety of persons and the protection of the environment.

During the reporting period, all NPP licensees fulfilled regulatory requirements. They also met expectations for most safety areas assessed by the Canadian Nuclear Safety Commission (CNSC). Although some NPP safety areas were judged to be below requirements at times during the reporting period, all safety areas at every Canadian NPP were judged in 2006 to meet or exceed CNSC requirements for the overall definition of programs as well as their implementation.

Safety-related issues that arose during the reporting period were addressed in an appropriate manner, although the resolution of many issues remains an ongoing priority. Reported events did not pose significant threats to persons or the environment (none were above level “1” on the International Nuclear Event Scale), and licensees followed up appropriately and effectively. During the reporting period, the CNSC did not have to engage in formal enforcement actions to resolve any safety-related issues at Canadian NPPs.

During the reporting period, all Canadian NPPs operated with acceptable safety margins, acceptable levels of defence-in-depth, and acceptable material and component conditions. The maximum annual worker doses at NPPs were well below annual dose limits. In addition, radiological releases from all NPPs were kept at approximately 1% of derived release limits.

During the reporting period, two licensees submitted applications to the CNSC to build new NPPs in Canada. Refurbishment of existing NPPs is also underway, and much activity is planned in the next reporting period and beyond. Various refurbishment projects involve replacing major reactor components and replacing and/or upgrading other safety-significant systems. This work will have a positive effect on safety in general and will increase some safety margins.

At the Third Review Meeting of the Convention, several actions were assigned to Canada regarding subjects that were unique to Canada or of interest to other countries. During the reporting period, the CNSC and the Canadian nuclear industry made progress in addressing the assigned actions and some major activities will continue into the next reporting period. For example, the CNSC is working to enhance the regulatory framework for both new NPPs and those that are being refurbished. Both the CNSC and the industry are also focusing on the possibility of implementing periodic safety review and on the improvement of safety margins for large loss of coolant accidents.

Finally, in response to another action on Canada, the CNSC requested a mission of the Integrated Regulatory Review Services. Pending discussion with the International Atomic Energy Agency, this mission is planned to occur in the next reporting period.

The President of the CNSC will step down as the continuing President of the Third Review Meeting of the Convention. She will assist her successor, as appropriate, to continue improvements to the Review Meetings that were started over the last review period. Canada remains fully committed to the principles and implementation of the Convention.

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
ALARA	As Low As Reasonably Achievable, social and economic factors being taken into account.
Bruce Power	Bruce Power Inc.
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
CEAA	*Canadian Environmental Assessment Act*
CMD	Commission Member Documents are prepared for Commission hearings and meetings by CNSC staff, proponents and intervenors (each CMD is assigned a specific identification number)
CNSC	The Canadian Nuclear Safety Commission as an organization
CNSC Staff	The staff of the Canadian Nuclear Safety Commission
COG	CANDU Owners Group Inc.
Commission	The tribunal component of the Canadian Nuclear Safety Commission
Convention	*Convention on Nuclear Safety*
CSA	Canadian Standards Association
desktop review	All verification activities limited to the review of documents and reports submitted by licensees (this includes quarterly technical reports, annual compliance reports, special reports and documentation related to design, safety analysis, programs and procedures)
DRL	Derived release limits
EA	Environmental assessment
ECC	Emergency core cooling
EIC	Emergency information centre
EIS	Environmental impact study
EMO	Emergency Management Ontario
event review	All verification activities related to reviewing, assessing and trending of licensees' event reports.
FAF	Fuelling against the flow—loading fuel bundles into the fuel channel in the direction opposite to normal coolant flow
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.
FWF	Fuelling with the flow—loading fuel bundles into the fuel channel in the same direction as normal coolant flow
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
GSS	Guaranteed shutdown state
HFE	Human factors engineering
HFEPP	Human factors engineering program plan
HQ	Hydro-Québec
HTS	Heat transport system

lay-up	A special configuration into which a plant is placed to prevent system and component degradation during extended periods of shutdown
IAEA	International Atomic Energy Agency
INES	International Nuclear Event Scale
IRRS	Integrated Regulatory Review Services
IRS	Incident reporting system
ISR	Integrated safety review
LOCA	Loss of coolant accident
LVR fuel	Low-void-reactivity fuel
mSv	Millisievert
MW	Megawatt
NBEMO	New Brunswick Emergency Measures Organization
NBPN	New Brunswick Power Nuclear Corporation
NEA	Nuclear Energy Agency
NGO	Non-governmental organization
NPP	Nuclear power plant
NRCan	Natural Resources Canada
NSCA	*Nuclear Safety and Control Act*
OECD	Organization for Economic Cooperation and Development
OLC	Operational limits and conditions
OP&P	Operating policies and principles
OPA	Ontario Power Authority
OPEX	Operating experience
OPG	Ontario Power Generation Inc.
OSCQ	Organisation de sécurité civile du Québec
PMUNE-G2	Plan des mesures d’urgence nucléaire externe à la centrale Gentilly-2
PNERP	Province of Ontario Nuclear Emergency Response Plan
PRRIP	Power Reactor Regulation Improvement Program
PSA	Probabilistic safety assessment
PSR	Periodic safety review
QA	Quality assurance
reporting period	April 2004 to March 2007
RIDM	Risk-informed decision making
S-99	CNSC regulatory standard *Reporting Requirements for Nuclear Power Plants*
SDR	Significant Development Report
SDS	Shutdown system
SOE	Safe operating envelope
SSCs	Structures, systems and components
Type I Inspection	All verification activities related to on-site audits and evaluations of licensee programs, processes and practices
Type II Inspection	All verification activities related to routine (item-by-item) checks and rounds
USNRC	United States Nuclear Regulatory Commission
WANO	World Association of Nuclear Operator

CHAPTER I
INTRODUCTION

A GENERAL

Canada was one of the first signatories of the *Convention on Nuclear Safety* (the Convention), which came into force on October 24, 1996. Canada has endeavoured to fulfill its obligations under the Convention as demonstrated in the Canadian reports presented at the previous Review Meetings of the Convention held in April 1999, 2002 and 2005, respectively.

The President of the CNSC will step down as the continuing President of the Third Review Meeting. As appropriate, she will assist her successor to continue the improvements made to the Review Meetings that started over the last review period. Canada remains fully committed to the principles and implementation of the Convention.

This fourth 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, the CANDU Owners Group, Foreign Affairs and International Trade Canada, Natural Resources Canada, Public Safety Canada and the emergency response organizations of the provinces of New Brunswick, Ontario and Québec.

Scope

As required by Article 5 of the Convention, this fourth Canadian report demonstrates how Canada fulfilled its obligations under Articles 6 to 19 of the Convention during the reporting period, which extends from April 2004 to March 2007. The report follows closely the guidelines, regarding form and structure, which were established by the contracting parties under Article 22 of the Convention. This fourth 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 third Canadian report. A particular focus is placed on the progress on issues identified during the review of the third Canadian report.

As agreed at the Third Review Meeting, 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 Section 19 (viii) of this report. Spent fuel and radioactive waste are addressed more thoroughly in the second *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 2005.

Contents

Chapter II of this report describes aspects of nuclear power policy, production, and regulation in Canada. Although these are not directly applicable to any particular article of the Convention, they represent the context within which the articles are met.

Chapter III provides an overview of the report's conclusions and includes summaries of the following:

- the fulfillment of the articles of the Convention;
- progress on the actions on Canada from the Third Review Meeting (see subsection B.2 of this chapter);
- important safety issues not addressed by the actions on Canada from the Third Review Meeting, as well as new ones that emerged during the reporting period; and
- planned future activities to address these actions on Canada and other safety issues.

Chapter IV includes detailed material that demonstrates how Canada implemented its obligations under Articles 6 to 19 of the Convention during the reporting period. Chapter IV 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), and
- Part D–Safety of Installations (Articles 17 to 19).

The sections in each chapter begin with a box that contains the text of the relevant article of the Convention. For each article, the description of Canada's provisions to fulfill the relevant obligations is organized in subsections that follow the structure and numbering of the obligations as presented in the article itself. Where a breakdown into finer subsections is used, lowercase letters have been appended to the article numbering for reference purposes.

There are two bodies of supplementary information at the end of the report. The appendices (identified by letters A through G) provide detailed information that is relevant to more than one article. The annexes provide information that is:

1. directly relevant to the manner in which Canada fulfills a particular article; and
2. a) essentially equivalent to information that has already been reported in previous Canadian reports (under the same article), or
   b) licensee- or province-specific.

Each annex's number corresponds to the number of the article to which the annex is relevant.

References

The full text of the first, second and third Canadian reports, as well as related documents, can be found on the Web sites of the CNSC and the IAEA (see Appendix A for Web site addresses). 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.

A list of Web sites of relevant organizations mentioned throughout this report is included in Appendix A. This fourth Canadian report will be available on the CNSC Web site in 2007, in both of Canada's official languages (English and French).

B OUTCOME OF THE THIRD REVIEW MEETING

At the Third Review Meeting of the Convention, held in Vienna in April 2005, Canada presented its report to an audience of more than 34 participants representing 18 countries. Canada also responded to comments and questions from numerous countries, such as China, Finland, Germany, Hungary, Japan, Korea, Pakistan, and the United States. These comments and questions pertained to such topics as CNSC independence, the risk-informed regulatory approach, plant restarts and refurbishments, licence re-issuance and periodic safety review (PSR). The following sections list the good practices and the follow-up actions identified at the Third Review Meeting.

B.1 Good Practices

Peer review of the third Canadian report included the following good regulatory and industry practices:

- the regulatory process is open and transparent to the public;
- the industry regularly shares operating experience so that lessons are quickly learnt and integrated into operations;
- there is ongoing, systematic regulatory oversight of licensee safety performance by the regulator in several safety areas;
- the regulator systematically assesses licensee safety culture, quality management and compliance with the legislative and regulatory framework; and
- the regulator implements modern management systems for quality management as part of its initiatives to improve effectiveness and efficiency.

A brief update on these good practices is provided in Chapter III (Summary).

B.2 Follow-up Actions and Status

Canada accepted several actions to improve safety, which include the following:

1. developing the regulatory approach for refurbishment and life extension of nuclear power plants (NPPs);
2. modernizing the regulatory framework for licensing new reactor projects;
3. maintaining safety competence in the nuclear industry and the regulatory body;
4. completing the quality management program implementation in the regulatory body;
5. improving the rating system used to evaluate licensee performance;
6. finalizing the Power Reactor Regulation Improvement Program;
7. evaluating the use of periodic safety review in Canada;
8. enhancing a risk-informed performance-based regulatory approach;
9. continuing the program to improve safety margin for large loss of coolant accidents;
10. continuing the project on safe operating envelope; and
11. hosting an Integrated Regulatory Review Services mission.

As a good practice, Canada elected to prepare a report to summarize the progress on each action in the first year after the Third Review Meeting, The report, *Third Review Meeting – Convention on Nuclear Safety First Anniversary Report*, was issued in April 2006 and is available on the CNSC Web site.

The current progress on these action items is summarized in Chapter III (Summary)

CHAPTER II
CONTEXT

A GENERAL

The Government of Canada has funded nuclear research and has supported the development and the use of nuclear energy and related applications for many decades.

The first nuclear power plant (NPP) in Canada began operation in 1962. Today, the Government of Canada funds research and development activities primarily related to Canadian Deuterium Uranium (CANDU) technology in the amount of approximately $100 million annually. In addition, the nuclear industry provides, via the CANDU Owners Group (COG), approximately $33 million annually for research that supports operating NPPs.

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

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

B NATIONAL NUCLEAR POLICY

Nuclear energy falls within federal jurisdiction. The Government of Canada gives high priority to the safety and protection of persons and the environment with respect to operations of the nuclear industry and has established a comprehensive and robust regulatory regime. Canada’s nuclear regulator is the Canadian Nuclear Safety Commission (CNSC), an independent federal agency. Other major federal government departments involved in the Canadian nuclear industry include the following:

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

The *Nuclear Safety and Control Act* (NSCA), the *Nuclear Energy Act*, the *Nuclear Fuel Waste Act* and the *Nuclear Liability Act* are the centerpieces of Canada's legislative and regulatory framework for nuclear matters. The NSCA is the key piece of legislation for ensuring the safety of the nuclear industry in Canada. Other legislation that provides environmental protection and worker protection, such as the *Canadian Environmental Protection Act* and the *Canada Labour Code*, respectively, complements these acts.

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

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

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

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

C REGULATORY, LEGISLATIVE AND OTHER DEVELOPMENTS

C.1 Clarification of Licensing Framework for new NPPs

In response to indications that new NPPs might be built in Canada to meet future energy needs, the CNSC issued an information document, *Licensing Process for New Nuclear Power Plants in Canada* (INFO-0756) in 2006. The document clarified the current licensing process in the context of the NSCA and its associated regulations. The CNSC also issued supplementary information on the design review process for new NPPs in 2007.

C.2 New Brunswick *Electricity Act*

The *Electricity Act* came into force in the province of New Brunswick on October 1, 2004. One of the provisions in this act was the restructuring of New Brunswick Power Corporation into a corporation with four subsidiary companies wholly owned by the Province of New Brunswick. One of these companies is the New Brunswick Power Nuclear Corporation (NBPN), which is the new licensee for Point Lepreau.

C.3 Canadian Nuclear Utility Executive Forum

At the Third Review Meeting of the *Convention on Nuclear Safety*, leaders of organizations involved in the nuclear industry demonstrated a shared interest in maintaining a focus on nuclear safety during the period between Review Meetings. Accordingly, at a meeting of the CNSC President and the Chief Executive Officers of Canadian NPP licensees in 2006, a forum was founded to facilitate safety improvements and to discuss strategic issues. The Canadian Nuclear Utility Executive Forum (CNUEF) includes the Chief Nuclear Officers of NPP licensees and the CNSC executives responsible for their regulation. During the reporting period, the CNUEF discussed projects to advance progress on several initiatives important to nuclear safety. Some of these projects are described in subsections 14 (i) c and 14 (i) f.

D NUCLEAR POWER INDUSTRY IN CANADA

D.1 List of Existing Nuclear Power Plants in Canada

Of the 22 nuclear reactor units in Canada, 18 are currently licensed to produce power. During the reporting period, two reactor units remained de-fuelled, two units progressed toward a safe storage state and one unit was returned to service (see subsection D.3 of this chapter for details). The Canadian NPPs are operated by four licensees:

1. Ontario Power Generation Inc. (OPG), a private company wholly owned by the Province of Ontario;
2. Bruce Power Inc. (Bruce Power), a private corporation;
3. Hydro-Québec (HQ), a crown corporation of the Province of Québec; and
4. New Brunswick Power Nuclear Corporation (NBPN), a crown corporation of the Province of New Brunswick.

These four licensees operate five NPPs involving seven licences:

- in the province of Ontario: Darlington (one licence), Pickering (one licence each for Pickering A and B) and Bruce (one licence each for Bruce A and B);
- in the province of Québec: Gentilly-2 (one licence); and
- in the province of New Brunswick: Point Lepreau (one licence).

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

The NPPs in Canada use pressurized heavy water reactors of the CANDU design. A full description of CANDU reactors was provided in the first and second Canadian reports.

D.2 Electricity Market

As reported in the third Canadian report, the electricity sector in the province of Ontario was opened to competition on May 1, 2002. Also reported previously, the Government of Ontario undertook a series of studies in 2004 to determine what further changes, if any, were required to the electricity market. In particular, the government assessed the rate structure for the market and the role of OPG in this market. These studies resulted in the Ontario *Electricity Restructuring Act*, 2004, which reorganized Ontario's electricity system. To address the need for consumer price stability, the legislation established a hybrid electricity market (part regulated and part competitive) in Ontario. This involved taking the major hydroelectric stations and the NPPs owned by OPG out of the competitive market and placing them under rate regulation by the Ontario Energy Board. The legislation also created a new Ontario Power Authority (OPA) to ensure long-term supply in Ontario. The OPA will forecast future demand and the potential for conservation and renewable energy and prepare an integrated system plan for generation, transmission and conservation.

In 2005, the OPA issued its *Supply Mix Advice and Recommendations* report, which presented recommendations to the Ontario Minister of Energy on options for future development of Ontario’s electricity system.

As part of its response to the OPA report in 2006, the Government of Ontario directed the OPA to plan for nuclear capacity to meet base-load electricity requirements, but to limit the installed in-service capacity of nuclear power over the life of the plan to the existing installed capacity of 14,000 MW. The plan extends to the year 2027.

The Government of Ontario directed OPG to undertake feasibility studies for refurbishing units at the Pickering and Darlington sites. OPG has also been instructed to begin the work for an environmental assessment (EA) of the construction and operation of new units at an existing NPP site (Darlington).

There were no major developments in the electricity markets in the provinces of Québec or New Brunswick that substantially affected the plans or operations of Gentilly-2 or Point Lepreau during the reporting period.

D.3 Life Extension Projects at Existing NPPs

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

Pickering A Return to Service

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

In 2005, OPG decided not to return Units 2 and 3 to service. The decision was based on the business case and not on safety concerns or insurmountable technical challenges.

OPG determined that the material condition of Units 2 and 3 was inferior to that of Units 1 and 4. For example, the steam generators in Units 2 and 3 were in much worse condition than those in Units 1 and 4. Additional monitoring and inspection of these steam generators and other components meant that OPG would be facing longer outage times in the years ahead. These units are being placed in a safe storage condition, in which the fuel and heavy water are being removed from the reactors. Some Unit 2 and 3 systems will remain energized, providing common system support to the operation of Units 1 and 4. Units 2 and 3 will be maintained in the safe storage state until the entire NPP would be shut down for decommissioning.

Refurbishment of Pickering B

Pickering B came into service in 1983 and could continue to safely operate for almost another decade before requiring refurbishment. At the end of their predicted service lives, the units could be shut down or refurbished. In 2006, OPG submitted a letter of intent and project description to the CNSC regarding the potential refurbishment of Pickering B. The earliest start date for the refurbishment outage would be some time in 2012.

Refurbishment of Bruce A

Bruce A came into service in 1977. Unit 2 was put into long-term lay-up in 1995, while Units 1, 3 and 4 were put into lay-up in 1997 and 1998. Units 3 and 4 were successfully returned to service in January 2004 and October 2003, respectively.

In 2004, Bruce Power submitted a letter of intent and project description to the CNSC regarding the refurbishment of Units 1 and 2 at Bruce A for life extension and continued operation. Refurbishment work began during the reporting period.

Refurbishment of Gentilly-2

Gentilly-2 came into service in 1983. In 2001, Hydro-Québec began a safety review as part of the Gentilly-2 refurbishment project. During the reporting period, Hydro-Québec continued the review and technical and regulatory planning. At the end of 2008, Hydro-Québec will make a decision regarding refurbishment of Gentilly-2.

Refurbishment of Point Lepreau

Point Lepreau came into service in 1983. In 2005, the Government of New Brunswick announced that NBPN would proceed with the refurbishment of Point Lepreau. Atomic Energy of Canada Limited (AECL) was chosen to be the general contractor for this major project.

Since receiving the approval to proceed, NBPN has undertaken detailed engineering, outage planning and procurement activities in advance of an eighteen-month shutdown. This refurbishment outage is scheduled to begin in April 2008.

D.4 Applications for Site Licences for New Reactors

In the summer of 2006, two organizations submitted applications for licences to prepare sites for the future construction of NPPs. In the first application, Bruce Power identified two possible sites, both within the existing boundary of the Bruce site. In the other application, OPG identified a site within the existing boundary of the Darlington site.

CNSC staff will review the suitability of the proposed sites against relevant national and international standards, including publications of the IAEA. The CNSC has also determined that EAs will be required for each project pursuant to the *Canadian Environmental Assessment Act* (CEAA) and related regulations. A positive finding must also be made on the likely environmental effects for the consideration of any licensing action under the NSCA.

CHAPTER III
SUMMARY

A STATEMENT OF COMPLIANCE WITH ARTICLES OF THE CONVENTION AND OVERALL SUMMARY

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. Enabled by a modern and robust legislative framework, these measures are implemented by a regulator and NPP licensees that focus on the health and safety of persons and the protection of the environment. Typically, the Canadian approach to these measures is non-prescriptive; that is, the CNSC sets general regulatory requirements and NPP licensees develop specific provisions to meet the requirements. Provisions that are critical to safety are approved by the CNSC before licensed activity can begin. During the reporting period, all NPPs met the regulatory requirements and expectations in almost all safety areas assessed by the CNSC. Although some NPP safety areas were judged to be below requirements at times during the reporting period, all safety areas at every Canadian NPP were judged in 2006 to meet or exceed CNSC requirements for the overall definition of programs as well as their implementation.

Safety-related issues that arose during the reporting period were addressed in an appropriate manner, although resolution of many issues remains an ongoing priority. Reported events (the most significant ones are described in Appendix D) did not pose significant threats to persons or the environment and were only rated as Level “0” or “1” on the International Nuclear Event Scale (INES). Licensee follow-up was appropriate and effective. During the reporting period, the CNSC did not have to engage in formal enforcement actions to resolve any safety-related issues at Canadian NPPs, and many important issues related to safety were addressed in a collaborative manner. The non-prescriptive Canadian approach involved communication between the regulator and the NPP licensees to clarify requirements where necessary and to ensure that the proposed resolution of the issue would meet requirements. Canadian NPP licensees also collaborated on many projects to address safety issues and share information.

During the reporting period, all Canadian NPPs operated with acceptable safety margins, acceptable levels of defence-in-depth, and acceptable material and component conditions. At all NPPs, the maximum annual worker doses were well below annual dose limits. In addition, the radiological releases from all the NPPs were kept at approximately 1% of the derived release limits (defined in Section 15 d).

B FOLLOW-UP ON GOOD PRACTICES AND ACTIONS IDENTIFIED AT THE THIRD REVIEW MEETING

B.1 Good Practices

Good regulatory and industry practices were identified by the peer review of the third Canadian report. Those practices were continued and, in some cases, improved during the reporting period. A summary update of those practices is provided below, along with references to more complete descriptions in Chapter IV.

1. The regulatory process is open and transparent to the public.

During the reporting period, the CNSC continued to facilitate the public's participation in the regulatory process (see subsection 8.1 a) and continued to fulfill the part of its mandate related to disseminating information to all stakeholders. The CNSC established a committee to consult and communicate with non-governmental organizations on nuclear regulatory and policy matters. The CNSC also held hearings in communities most affected by the Commission's work, such as in Québec for matters related to Gentilly-2 (see subsection 8.2 b for more details).

2. The industry regularly shares operating experience so that lessons are quickly learned and integrated into operations.

During the reporting period, NPP licensees maintained their programs to collect and analyze information on operating experience. The licensees continued to review operating experience from both national and international sources and to incorporate it in their operations as appropriate (see Section 19 (vii) for details). Licensee participation in independent external audits, by organizations such as the World Association of Nuclear Operators and the IAEA's Operational Safety Assessment Review Teams, also facilitated the incorporation of lessons and experience from peers and external experts (see subsection 14 (ii) c for details).

3. The regulator demonstrates ongoing, systematic regulatory oversight of licensee safety performance in several safety areas.

During the reporting period, the CNSC maintained its program to promote and verify licensee compliance with regulatory requirements. A baseline compliance program, which includes a pre-determined set of inspections, was developed and implemented to help achieve regulatory effectiveness, efficiency, consistency, and clarity. CNSC staff also continued to assess licensees' operational programs and their implementation across a comprehensive set of safety areas (see subsection 7.2 (iii) c for details).

4. The regulator systematically assesses licensee safety culture, quality management and compliance with the legislative and regulatory framework.

During the reporting period, the CNSC maintained its program to promote and verify licensee compliance with regulatory requirements. The CNSC continued to gather data for use with its Organizational and Management Review Method. It also provided guidance to licensees to help them develop self-assessments of their safety culture (see Section 10 b for details).

5. The regulator implements modern management systems for quality management as part of its initiatives to improve effectiveness and efficiency.

During the reporting period, the CNSC continued to implement initiatives to improve effectiveness and efficiency. Management structure, planning, and other provisions are adjusted as necessary to respond to the changing demands of regulating the NPPs (see Article 8 for details; also refer to action #4 in Section B.2 of this chapter).

B.2 Actions on Canada

Chapter I lists several actions to improve safety, which stemmed from the peer review of the third Canadian report. During the reporting period, the CNSC and the industry made progress in addressing all the actions. Activities to address them will continue in the next reporting period. A summary update of progress on those actions is provided below, along with references to more complete descriptions in Chapter IV.

1. Develop the regulatory approach for refurbishment and life extension of NPPs

During the reporting period, the CNSC issued the regulatory guide *Life Extension of Nuclear Power Plants* (G-360) for public consultation (see subsection 7.2 (i) for details). Bruce Power and OPG are using the draft guide during their feasibility studies for the possible refurbishment of Bruce A and Pickering B, respectively.

2. <u>Modernize the regulatory framework for licensing new reactor projects</u>

During the reporting period, the CNSC issued an information document, *Licensing Process for New Nuclear Power Plants in Canada* (INFO-0756), to clarify the current licensing process in the context of the NSCA and its associated regulations. The CNSC also issued supplementary information on the design review process for new NPPs. The CNSC is developing regulatory standards that contain design requirements, site evaluation requirements, and safety analysis requirements for NPPs. The CNSC has several other regulatory policies, standards and guides in various stages of development that will also help form part of the regulatory framework for the licensing of new reactors (see subsection 7.2 (i) for details).

During the reporting period, the nuclear industry, the CNSC, and the Canadian Standards Association (CSA) worked together to strengthen the nuclear standards program. Several new standards were issued and many others were updated or re-affirmed (see subsection 7.2 (i) for details).

The planned improvements to the CNSC regulatory document program (see subsection 7.2 (i) for details) should help streamline the development of the regulatory framework for new NPPs.

3. <u>Maintain safety competence in the nuclear industry and regulatory body</u>

During the reporting period, the industry and the CNSC took many steps to address the issue of maintaining safety competence of the workforce. These steps were aimed at retaining and enhancing both the number of skilled workers and their knowledge and expertise. A symposium in 2006 identified the human resources issues facing the nuclear industry and pointed to specific steps to be taken in a multi-faceted strategy to meet the industry's present and future human resources needs. The provisions include workforce capability analysis, hiring programs, training programs, and knowledge retention programs (see subsection 11.2 b for details). The NPP industry continued to replenish its workforce through aggressive hiring campaigns and strengthened its ties with universities and colleges. The CNSC initiated similar programs (see subsection 8.1 e).

4. <u>Complete the quality management program implementation in regulatory body</u>

During the reporting period, the CNSC formally committed to the establishment of a corporate-wide management system in accordance with the requirements and guidance in the IAEA Safety Standard *Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety* (GS-R-1), draft IAEA standard *Management Systems for Regulatory Bodies* (DS-113), and accompanying safety guides. Furthermore, the CNSC established a Quality Council headed by the Chief Quality Officer, a position held by the CNSC Executive Vice-President of Operations. A new division for Internal Quality Management was also established. CNSC staff is planning to issue a revision of its management system manual in 2007 (see subsection 8.1 d for details).

5. <u>Improve the rating system used to evaluate licensee performance</u>

The rating system, as described in Appendix G, has not changed since the third Canadian report. As described in subsection 7.2 (ii) e, additional detailed guidance was provided during the reporting period to CNSC staff related to application of the existing system when rating NPP licensees. Progress was made toward considering all applicable data and achieving objectivity and consistency (for the different licensed NPPs from one rating period to the next and from one safety area to the next).

During the reporting period, CNSC staff clarified some of the requirements and expectations against which the licensee's programs are rated. For example, references to regulatory standards for reliability programs and probabilistic safety assessments (see subsection 14 (i) d) were added to operating licences. Also, CNSC staff defined broad performance objectives for each of the safety areas and programs. In the *Annual CNSC Staff Report for 2006 on the Safety Performance of the Canadian Nuclear Power Industry* (available on the CNSC Web site listed in Appendix A), CNSC staff rated the implementation of the licensees' safety areas and programs against these performance objectives.

6. Finalize the Power Reactor Regulation Improvement Program

During the reporting period, the Power Reactor Regulation Improvement Program (PRRIP) deliverables were either completed or incorporated in the corrective action plan developed in preparation for the Integrated Regulatory Review Services (IRRS) mission (see Action 11 below).

7. Evaluate the use of periodic safety review in Canada

During the reporting period, licensees planning or contemplating refurbishment of their NPPs developed Integrated Safety Reviews (ISRs) for submission to the CNSC. ISRs are one-time applications of the IAEA PSR process to a refurbishment project. Although the existing safety assessment process for operating licence renewal in Canada is similar to a PSR, the CNSC continued to consider the possible advantages of adopting PSRs for operating reactors. The CNSC reviewed the implementation of PSRs in other countries and engaged the NPP industry in a discussion of the issues involved in adopting PSRs. If the CNSC decides to use PSRs, it is anticipated that the process will be introduced and implemented in Canada over a period of several years. Additional details on PSR are provided in subsection 14 (i) f.

8. Enhance the risk-informed performance-based regulatory approach

During the reporting period, CNSC staff developed a risk-informed decision-making (RIDM) process for implementation in the regulation of NPPs. Detailed guidance was also developed to apply the process to decisions related to licensing and compliance, as well as planning, monitoring and reporting CNSC staff activities with respect to NPP regulation. CNSC staff began using the process on a limited, trial basis during the reporting period. See subsection 8.1 d for details. The implementation of the baseline compliance program described in subsection 7.2 (iii) c was also an enhancement of NPP regulation based on both risk and performance considerations.

9. Continue the program to improve safety margin for large loss of coolant accidents

During the reporting period, an industry-wide approach to this issue was adopted. The approach includes a study of the feasibility of design changes to restore analysed safety margins (for example, use of low-void-reactivity fuel), as well as the development and implementation of the Best Estimate Analysis and Uncertainty (BEAU) methodology as an alternate licensing methodology to demonstrate that existing safety margins continue to be adequate. In addition, the industry is evaluating global progress in risk-informed methods; including break preclusion and risk-informed inspection, to assess how these methods can be applied to large loss of coolant accidents (LOCAs) in CANDU reactors. Application of risk-informed methods should provide increased assurance of event prevention, which is the first line of defence.

The new Advanced CANDU Reactor (ACR-1000) is being designed to have a negative coolant void reactivity coefficient that would effectively eliminate the large LOCA margin issue in new CANDU reactors (see subsection 14 (i) c for details).

10. Continue the project on safe operating envelope

During the reporting period, the Canadian NPP licensees continued their safe operating envelope (SOE) projects, which are intended to better define the safe operating limits and facilitate their implementation in operating documentation. OPG and Bruce Power have prepared or are preparing documentation on the operational safety requirements for some safety-significant systems. This will provide a definitive and maintainable link between safety analysis and operating documentation, creating a comprehensive list of the limits for operation of a given system. The approach being taken by NBPN and Hydro-Québec involves aligning CANDU Owners Group (COG) guidelines with the SOE methodology for special and other safety systems and revising operating documents accordingly (see subsection 19 (ii) b for details).

11. Host an Integrated Regulatory Review Services mission

During the reporting period, the CNSC officially requested an Integrated Regulatory Review Services (IRRS) mission from the IAEA. In preparation for the IRRS mission, a self-assessment review team (SART) completed an assessment that outlined recommendations and suggestions for improvements at the CNSC. Five corporate-wide improvement projects were identified to address the following areas:

1. management system;
2. integrated planning and performance management;
3. regulatory compliance processes;
4. regulatory licensing processes; and
5. leadership development.

A corrective action plan was drafted to respond to the recommendations and suggestions and to establish an integrated plan to proceed with the implementation of the five improvement projects. Since the original request to the IAEA, the CNSC, based on experience with other IRRS missions, decided to expand the scope of the IRRS mission to include uranium mines and mills and nuclear substances. Subject to discussions between the CNSC and IAEA, the IRRS peer review is planned for the next reporting period. Details are provided in subsection 8.1 d.

C SUMMARY OF PLANNED ACTIVITIES TO IMPROVE SAFETY

Many of the safety improvements described in this report are ongoing and their completion will result in significant safety improvements at Canadian NPPs. A summary of anticipated progress on the most significant activities, along with references to detailed descriptions in Chapter IV, is provided below.

There is significant refurbishment activity underway at Canadian NPPs, and much activity is planned and anticipated in the next reporting period and beyond. The various refurbishment projects involve the replacement of major components. For example, Bruce Power received regulatory approval to replace the major heat transport system components (fuel channels, feeders and steam generators) as well as the calandria tubes at Bruce A Units 1 and 2. These replacements will return refurbished reactors closer to their original state, and other safety-significant systems will be enhanced or upgraded. This will have a positive effect on safety in general, and some analyzed safety margins will increase as a result (see subsection 14 (i) e for details).

During the next reporting period, licensees intend to complete the implementation of their projects to reassure the environmental qualification of safety and safety-related systems. These projects, begun several years ago, will foster greater confidence that those systems will operate as intended during all design basis accidents (see subsection 14 (ii) b for details).

During the next reporting period, licensees plan to implement documents already developed in their Severe Accident Management Guidelines (SAMG) project. The licensees intend to adapt the generic SAMG strategies and guides to each NPP and interface the SAMG guides with the control room emergency operating procedures, validate the SAMG documentation against a wide variety of scenarios, and provide the emergency response organization with the training necessary to implement severe accident management strategies during emergencies. Validation exercises are planned in the next reporting period to verify the effectiveness of the strategies and documentation. Once complete, the project will extend the scope of severe accident management beyond the existing emergency operating procedures. In the event that significant core damage occurs or is imminent, the implemented strategy will enable licensees to take all reasonable measures with any available equipment, in attempts to mitigate core damage and releases from containment (see Section 19 (iv) for details).

During the next reporting period, OPG will complete the remaining major improvement to permanently address lessons learned during the loss of the electricity grid (blackout) of August 14, 2003, at Pickering. The auxiliary power system, which is designed with two combustion turbine units to supply power during a blackout, is on schedule for in-service availability in 2007 (see Article 19).

There is also a strong commitment to continue addressing the actions on Canada, as described above, and many related activities are planned. Some of the activities to address large LOCA safety margins are well established and will continue into the next reporting period. These include the following (see subsection 14 (i) c for more details):

- continuation of core conversion (change of fuelling direction) at Bruce B;
- testing of low-void-reactivity (LVR) fuel at Bruce; and
- development of BEAU methodology and implementation by Bruce Power and OPG.

The CNSC and licensees are strongly committed to the ongoing assessment of the advantages and issues related to possible implementation of PSR.

The CNSC intends to implement its RIDM process more fully. The CNSC is also planning to continue enhancing the regulatory framework in several key areas.

Finally, the CNSC has requested an IRRS mission. Pending discussion with the IAEA, it is likely to occur in the next reporting period.

CHAPTER IV
COMPLIANCE WITH ARTICLES OF THE CONVENTION

PART A
General Provisions

Part A of Chapter IV consists of one Article.

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.

The safety of all existing NPPs in Canada was fully reviewed at the times of their initial licensing. Both the licensees and the regulator have continued to conduct updated as well as broad assessments since then (for example, updates to the safety report, probabilistic safety assessments, and licence renewal assessments). Safety assessments are also conducted in response to significant events and national and international operating experience. Licensees and the regulator have also conducted many detailed verification activities in support of ongoing operation. Details are provided in the first and second Canadian reports.

Emerging significant issues that require immediate action are handled on a priority basis using provisions described in Article 7 (for example, issuance of orders or licensing actions). Safety issues that can be addressed over a longer period without compromising safety are handled in other ways, such as through the Generic Action Item (GAI) program. Upgrades have been made to maintain safety margins and incrementally enhance safety, as warranted.

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

PART B
Legislation and Regulation

Part B of Chapter IV consists of three Articles:

Article 7 – Legislative and Regulatory Framework
Article 8 – Regulatory Body
Article 9 – Responsibility of the 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.

7.1 Establishment of the Legislative and Regulatory Framework

7.1 a General

The CNSC operates within a modern and robust legal framework that includes the following elements:

- law, which includes legally enforceable instruments such as acts, regulations, licences and orders; and
- supporting regulatory documents, such as policies, standards, guides, notices, procedures and information documents, which support and provide further information on these legally enforceable instruments (regulatory documents are described in subsection 7.2 (i)).

The *Nuclear Safety and Control Act* (NSCA) is the top tier of Canada's nuclear regulatory framework and is described in subsection 7.1 b. Regulatory documents that are referenced in CNSC licences are also legally binding to licensees. Licences are described in detail in subsection 7.2 (ii).

7.1 b 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; and
- 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 growth in Canada's nuclear industry and nuclear technology — and to focus more on health, safety, security and environmental protection — updated legislation was required for more explicit and effective nuclear regulation. In response to this requirement, Canadian Parliament passed the *Nuclear Safety and Control Act* (NSCA) in 1997. The new law came into force on May 31, 2000, and binds Canada's federal and provincial Crowns as well as the private sector.

Whereas the *Atomic Energy Control Act* encompassed both regulatory and developmental aspects of nuclear activities, the NSCA separates these two functions in law. The NSCA also provided a distinct identity to the new regulatory agency, the Canadian Nuclear Safety Commission[1] (CNSC), which replaced the Atomic Energy Control Board.

The CNSC is a quasi-judicial administrative tribunal that establishes regulatory policy on matters relating to health, safety, security and the environment. It also makes independent licensing decisions and legally binding regulations. The Commission 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; and
- 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 referred to in the first bullet.

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; and
  - research.

[1] The Canadian Nuclear Safety Commission or CNSC refer to the total organization. The tribunal component is referred to as the Commission and the staff component as CNSC staff.

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

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

- clearly defined powers for inspectors, bringing their powers in line with modern legislative practices;
- increased penalties for non-compliance, bringing them in line with current practices;
- clear appeal provisions for orders of inspectors and officers designated by the Commission;
- provision for the Commission to re-determine decisions in light of new information;
- the authority to order remedial actions in hazardous situations and to require responsible parties to bear the costs of decontamination and other remedial measures;
- the authority to include licence conditions requiring power to demand financial guarantees for operation, decommissioning and waste management as a condition of receiving a licence; and
- recovery of the costs of regulation from entities licensed under the NSCA.

7.1 c Other Legislation

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

Nuclear regulation is clearly under federal jurisdiction. However, under the Canadian constitution, provincial laws may also apply to nuclear regulation in areas that do not relate directly to nuclear energy and that do not conflict with federal law. For example, provincial environmental legislation applies to nuclear facilities (as in the case of the April 2005 event at Bruce B described in Appendix D). Where both federal and provincial laws may apply, the CNSC tries to avoid duplicative effort by seeking cooperative arrangements with federal and provincial bodies that have regulatory responsibilities or expertise in these areas. Such arrangements are authorized by the NSCA in order to avoid regulatory overlap. The NSCA also provides authority for the Commission and the Governor in Council to incorporate provincial laws and regulations by reference.

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

- the *Nuclear Energy Act*;
- the *Nuclear Liability Act;*
- the *Nuclear Fuel Waste Act*;
- the *Emergencies Act*;
- the *Emergency Preparedness Act*; and
- the *Canadian Environmental Assessment Act.*

7.1 d Regulations Issued under the *Nuclear Safety and Control Act*

The following regulations are issued under the NSCA:

- *General Nuclear Safety and Control Regulations;*
- *Radiation Protection Regulations;*
- *Class I Nuclear Facilities Regulations;*
- *Class II Nuclear Facilities and Prescribed Equipment Regulations;*
- *Nuclear Substances and Radiation Devices Regulations;*
- *Packaging and Transport of Nuclear Substances Regulations;*
- *Uranium Mines and Mills Regulations;*
- *Nuclear Security Regulations;*
- *Nuclear Non-proliferation Import and Export Control Regulations;*
- *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations*; and
- *Canadian Nuclear Safety Commission Rules of Procedure*.

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

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

7.2 Provisions of the Legislative and Regulatory Framework

Various CNSC improvement initiatives related to provisions of the regulatory framework were described in the third Canadian report under the title of the Power Reactor Regulation Improvement Program (PRRIP), which included projects related to licensing (subsection 7.2 (ii)) and compliance (subsection 7.2 (iii)). The PRRIP initiatives were either completed or incorporated into the broader Integrated Improvement Initiatives Program (see subsection 8.1 d).

In 2006, the CNSC established a new Regulatory Policy Committee responsible for the strategic direction and high-level coordination and integration of the CNSC's regulatory framework.

7.2 (i) Regulatory Documents

Regulatory documents support the CNSC's regulatory framework by expanding on 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 issues (as of the end of the reporting period) four types of regulatory documents: policies, standards, guides, and notices. These classifications, which are under review, are defined in subsection 7.2 (i), which also describes the processes used to develop regulatory documents and approaches for incorporating standards in NPP operating licences. Annex 7.2 (i) also includes tables showing available published and draft regulatory documents.

<u>Use of Other Standards in the Development of CNSC Regulatory Documents</u>

As outlined in CNSC regulatory policy *Regulatory Fundamentals* (P-299) the CNSC sets requirements using appropriate industry, national, international or other standards. The CNSC is committed to using other standards, as appropriate, in the effective implementation of its regulatory mandate in Canada. This good practice is in line with the Government of Canada's April 2007 *Cabinet Directive on Streamlining Regulation* and is consistent with the CNSC's vision of regulatory excellence. This commitment also applies to the CNSC's approach to quality management, requiring the organization to develop internal management systems and quality management processes based on IAEA recommendations for regulatory bodies.

The CNSC actively contributes to the development of IAEA safety standards. Several members of the CNSC staff are part of working groups and technical meetings to draft these standards. CNSC representatives also sit on the IAEA's Commission on Safety Standards and four Safety Standards Committees with the aim of overseeing the IAEA's safety standards and advising the IAEA on the overall program on the regulatory aspects of safety. IAEA standards continue to serve as references and benchmarks for the Canadian approach to nuclear safety, as they have for many years. Annex 7.2 (i) provides some examples of how IAEA standards have been used to develop CNSC regulatory documents.

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

During the reporting period, the nuclear industry, the CNSC, and the CSA collaborated to strengthen Canada's program for nuclear standards. A CNSC staff member is a member of the CSA Nuclear Standards Executive Committee. During the reporting period, the CSA greatly reduced the cycle time to issue standards. Eight new standards have been issued and many others have been updated or re-affirmed. Among the new CSA standards are:

- *Material standards for reactor components for CANDU nuclear power plants* (N285.6-05) and
- *Environmental qualification of equipment for CANDU nuclear power plants* (N290.13-05).

Regulatory Framework for New NPPs

The CNSC is updating its regulatory framework for new NPPs. The revised framework will draw upon international standards and best practices, including the IAEA's nuclear safety standards, to the extent practicable. These standards set out high-level safety goals and requirements that apply to all reactor designs; that is, they are technology neutral. Canada has been an active participant in the development of these IAEA standards, as well as the supporting technical documents that provide more specific technical requirements and best practices for the siting, design, construction, operation and decommissioning of new NPPs. These standards and technical documents have served as references and benchmarks for the CNSC's nuclear regulatory requirements for many years.

In 2006, the CNSC released an information document, *Licensing Process for New Nuclear Power Plants in Canada* (INFO-0756) and held a public information session about the document. The document clarifies the current licensing process in the context of the NSCA and sets the stage for a series of regulatory documents related to the licensing of proposed new NPPs. In 2007, the CNSC issued supplementary information on the design review process for new NPPs.

A preliminary study on regulatory documents required for the construction of new reactors has been completed. Several regulatory documents were identified, and some are in various stages of preparation. They draw upon international experience and best practices, including IAEA nuclear safety standards. Relevant examples are given in the following paragraphs.

Design requirements are being documented for the assessment of the licensability of new NPPs in Canada. The early development of these requirements (the "licensing basis" project) is described in Section 4.7 of the third Canadian report. A pre-consultation draft of the design requirements document was made available for trial use and comments in 2005. This draft was also provided to licensees considering life extension of existing reactors, to aid them in comparing existing units against modern standards.

Development of design requirements has continued through the regulatory document development process. The objective is to produce criteria for all principal NPP designs that are technology neutral to the extent practicable and that include the following:

- safety goals and objectives for the design;
- design principles to be used;
- requirements for managing the design;
- design requirements for structures, systems, and components;
- high-level requirements for environmental protection, radiation protection, ageing, human factors, security, safeguards, transportation, and accident and emergency response planning; and
- requirements for integrating safety analysis into the design.

Another high-priority CNSC regulatory document will be a set of site evaluation requirements for new NPPs that expand upon those found in the CNSC *Class I Nuclear Facilities Regulations*. These requirements will be based on the IAEA siting guide *Site Evaluation for Nuclear Installations* (NS-R-3) and will incorporate some additional requirements from the USNRC and STUK that were not included in NS-R-3. In addition to addressing radiological hazards, the new CNSC regulatory document will clarify expectations for assessing the effects of conventional external and human-induced hazards.

During the reporting period, the CNSC also issued draft regulatory standard *Safety Analysis for Nuclear Power Plants* (S-310) for public consultation and will seek to establish the standard's requirements in the next reporting period.

The establishment of the aforementioned regulatory requirements will represent a significant step toward addressing action #2 on Canada from the Third Review Meeting of the Convention.

<u>Guidance for Refurbishment Projects</u>

The CNSC issued the draft regulatory guide *Life Extension of Nuclear Power Plants* (G-360) for public consultation and plans to publish it in the next reporting period. The guide 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 reactor operation. In keeping with its regulatory mandate, the CNSC expects licensees to demonstrate that the following objectives are met for any life extension project:

1. The technical scope of the project takes into account the results of an EA (see subsection 17 (ii) a) and an ISR (see subsection 14 (i) e) and is adequately reflected in a safety improvement plan;
2. Programs and processes that take into account the special considerations of the project are established; and
3. The project is appropriately planned and executed.

The publication of G-360 will represent a significant step toward addressing action #1 on Canada from the Third Review Meeting of the Convention.

Ongoing Development of the CNSC Regulatory Framework

To respond to current and emerging needs in a more timely manner, the CNSC is updating its regulatory framework to make it simpler and more responsive while enhancing clarity. A major element of this development will involve the greater use of regulations to set regulatory requirements. The CNSC also plans to replace the current classes of regulatory documents (policies, standards, guides, and notices) with a new document class that will consolidate information into one package per subject area. These documents will recommend approaches for meeting particular aspects of regulatory requirements and expectations. They may also describe the philosophy, principles, or fundamental factors on which regulatory activities for their respective subject areas are based. This new classification system and other process initiatives will improve the regulatory document program's overall efficiency.

7.2 (ii) Licensing of Nuclear Power Plants

7.2 (ii) a General

Section 26 of the NSCA prohibits any person from preparing a site, constructing, operating, decommissioning or abandoning an NPP 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."

The licensing process under the NSCA is initiated by an application that the proponent sends to the CNSC. 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. This information and specified programs, when referenced in the licence, become legal requirements for licensees. Licences may also contain other terms and conditions, such as references to standards, which licensees must meet.

The CNSC's licensing system is administered in cooperation with federal and provincial government departments and agencies in such areas as health, environment, transport and labour. Before the CNSC issues licences, 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.

After a licence is issued, the CNSC carries out activities under a compliance program (see subsection 7.2 (iii) b, subsection 7.2 (iii) c, and subsection 7.2 (iv)) to ensure that the licensee continues to meet requirements. If CNSC staff identifies a non-compliance or an adverse trend that may eventually lead to a non-compliance, there is a range of possible actions the CNSC can take (see subsection 7.2 (iv)).

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

(1) a licence to prepare a site;
(2) a licence to construct;
(3) a licence to operate;
(4) a licence to decommission; and
(5) a licence to abandon.

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

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

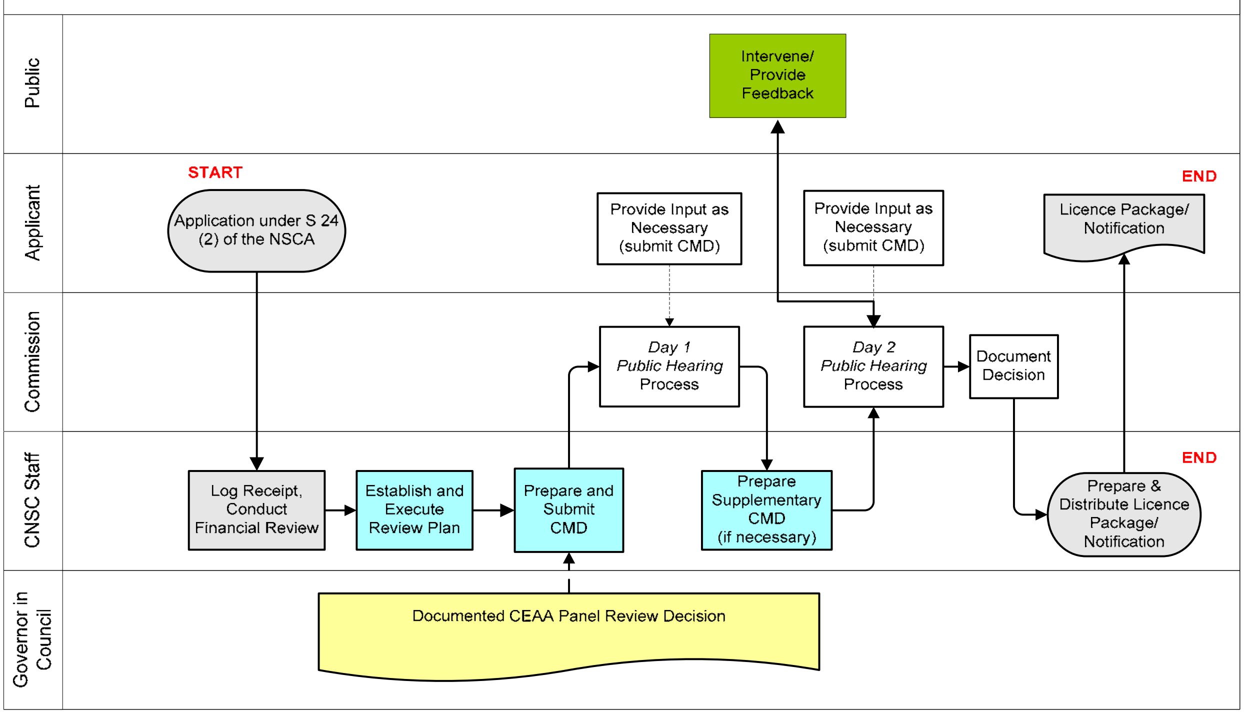
For new NPPs — in addition to the five licensing steps pursuant to the NSCA and its regulations — paragraph 5(1)(d) of the CEAA stipulates that an EA must be carried out to identify whether a project is likely to cause significant adverse environmental effects. The EA must take place before any federal 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.

7.2 (ii) b Process for Assessment of a Licence Application

The CNSC process for assessing a licence application under the NSCA is described in the *Canadian Nuclear Safety Commission Rules of Procedure*. Figure 7.1 depicts this process and the key activities to be carried out by the applicant, CNSC staff and the Commission. An application for licence renewal must contain sufficient information to meet regulatory requirements and demonstrate that the applicant is qualified to carry on the licensed activity. Information to be provided by the applicant when applying for a licence to prepare a site, construct, operate, or decommission a new NPP is specified in the following legal material:

- Section 3 of the *General Nuclear Safety and Control Regulations*;
- Sections 3 through 7 of the *Class I Nuclear Facilities Regulations* (as appropriate);
- the *Nuclear Security Regulations*;
- the *Radiation Protection Regulations*;
- the *Packaging and Transport of Nuclear Substances Regulations*; and
- the *Nuclear Substances and Radiation Devices Regulations.*

Figure 7.1: The Process for Obtaining an NPP Licence under the *Nuclear Safety and Control Act*



This information should be comprehensive and complete at the time the application is submitted, so that the CNSC's assessment of the application can be as effective and efficient as possible so that concerns can be identified as early as possible. This, in turn, will optimize the time needed by CNSC staff to carry out the regulatory assessment and to prepare recommendations regarding the application for the Commission's consideration.

Information on decommissioning plans and financial guarantees for the new NPP is also required early in the licensing process. The *Class I Nuclear Facilities Regulations* require an applicant to provide information on its proposed plan for decommissioning a nuclear facility or site; while the *General Nuclear Safety and Control Regulations* require information on financial guarantees to accompany a licence application. Financial guarantees are used to ensure that sufficient funds are available to ascertain that the facility does not pose any unnecessary risk in the event that the licensee can no longer operate the facility. To date, these have mostly been used for decommissioning a plant at the end of its useful life and for 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 Management Act*.

Early communications with the CNSC can help the applicant develop a good understanding of the regulatory requirements for new NPPs, as well as the licensing process and the information to be submitted in support of a licence application. It also enables the CNSC to plan for the regulatory review of an application and to be sure that qualified staff are available to carry out the assessment.

CNSC staff documents the conclusions and recommendations from its reviews in Commission Member Documents (CMDs) and submits them to the Commission. The Commission then makes the final decision on the issuance of the licence. As stated in subsection 7.2 (ii) a, the Commission can only issue licences to applicants that are qualified to operate the NPP and will adequately provide for the health and safety of persons and the protection of the environment.

Licences are typically issued with conditions, which may include "hold points" where CNSC approval is required before further work may proceed.

7.2 (ii) c Licence to Prepare a Site

Before issuing a licence to prepare a site for construction of a new NPP, the Commission must be satisfied that site characteristics having an impact on health, safety, security and the environment have been identified and that these characteristics can, and will, be considered in the design and operation of the new NPP. In addition, the Commission can issue a licence to prepare a site in either of the following situations:

- when a positive decision has been made on the EA as required by paragraph 5(1)(d) of the CEAA; or
- when the Governor in Council authorizes a project to proceed, even if the decision is negative, where effects can be justified in the circumstances in Section 37 of the CEAA.

The CNSC will also need to be assured that the site meets all applicable regulatory requirements.

The following aspects are considered in the evaluation of the suitability of a site over the life of an NPP:

- 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; and
- the population density, population distribution and other characteristics of the region, insofar as they may affect the implementation of emergency measures and evaluation of risks to individuals, the surrounding population and the environment.

The technical information arising from consideration of external events, site-specific characteristics and supporting safety assessments, are used as input into the design of the new NPP, and must be included in the application. Specific information required to obtain a licence to prepare a site is listed in Section 4 of the *Class I Nuclear Facilities Regulations*.

During this phase, the CNSC requires the applicant to publicly announce its intention to construct the facility and to hold public information meetings where the public can express its views and question applicant officials.

7.2 (ii) d 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 if the plant is constructed as designed. The onus is therefore on the applicant to show that there are no major safety issues outstanding when the Commission considers the application for a licence to construct.

The following is some of the information required in support of the application to construct a new NPP:

- 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 showing 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; and
- programs and schedules for recruiting and training operations and maintenance staff.

A more complete listing of the information required to obtain a licence to construct a new NPP is listed in Section 5 of the *Class I Nuclear Facilities Regulations.*

Upon receipt of the application, the CNSC performs a comprehensive assessment of the design documentation, preliminary safety analysis report and other information required by the regulations. This review involves rigorous engineering and scientific analysis as well as engineering judgment, taking into consideration the CNSC's experience and knowledge of best practices in NPP design and operation gained from existing power plants in Canada and around the world.

The CNSC reviews the analysis of those postulated accidents that define the major design requirements for the plant's safety features. At the construction licence stage, the CNSC requires analyses of enough postulated accidents in adequate detail to ensure that all major safety design requirements have been identified and show that reference dose limits can be met.

In addition to reviewing the information included in the application, the CNSC also verifies that any outstanding issues from the site preparation stage have been resolved.

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 confirmation that plant construction is consistent with the design and that QA requirements are being met.

7.2 (ii) e Licence to Operate

When applying for a licence to operate a NPP, it is the responsibility of the applicant to demonstrate to the CNSC that it has established appropriate safety management systems, plans and programs for safe and secure operation. The following is some of the information required in support of the application for a licence to operate:

- a description of the structures, systems and equipment at the NPP, including their design and operating conditions;
- the final safety analysis report; and
- proposed measures, policies, methods and procedures for:
  - commissioning systems and equipment;
  - 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 resulting from plant operation and decommissioning;
  - assisting off-site authorities in emergency preparedness activities, including assisting off-site authorities to deal with an accidental off-site release; and
  - maintaining nuclear security.

A more complete listing of the specific information required to obtain a licence to operate a new NPP is found in Section 6 of the *Class I Nuclear Facilities Regulations*. Appendix C provides an example list of program descriptions that accompany an application for an NPP operating licence. The CNSC assesses these programs using its standard definitions of safety areas and programs as well as the rating system described in Appendix G.

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 initial licence to operate will enable the operator to load nuclear fuel and begin commissioning the NPP. Commissioning activities serve to demonstrate that the NPP has been constructed in accordance with the design and that the systems, structures and components important to safety are functioning reliably. The initial licence to operate is typically issued with conditions (hold points) to load nuclear fuel, permit reactor start-up, and allow operation at power in steps up to the design rating of the plant. All relevant commissioning tests must be satisfactorily completed before hold points are relinquished.

<u>Licence Periods</u>

Historically, operating licences were issued for a renewable period of two years. This permitted CNSC staff to closely scrutinize licensee performance and also provided frequent opportunities for public intervention during public hearings involving applications for licence renewals. In 2002, the CNSC introduced flexible licence periods to enable it to regulate NPPs in a more risk-informed manner, through the adjustment of the licence period to the licensee's performance and findings of compliance-verification activities. This means that a shorter licence period will continue to be an option where overall licensee performance is unsatisfactory or because of other considerations.

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

Licence Renewals

For an operating licence renewal, the licensee must indicate any changes in information that was submitted in the previous application. The CNSC plans and conducts a balanced assessment of the licensee programs and activities, with priority placed on certain areas based on performance history, risk and expert judgement. The assessment is used to provide the Commission with a comprehensive review of the licensee and the facility and a supported staff recommendation for any licensing decision, as well as to guide ongoing regulatory activities.

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

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

The CNSC rating system is used to summarize CNSC staff's assessments for the licence renewal and aids in evaluating licensee programs and their implementation, as measured against CNSC regulatory requirements and performance expectations. The rating system consists of five categories:

- "A" – Exceeds requirements;
- "B" – Meets requirements;
- "C" – Below requirements;
- "D" – Significantly below requirements; and
- "E" – Unacceptable.

These categories are used to summarize licensee programs and performance in nine safety areas.

This rating system is also used in producing the annual CNSC staff report on the safety performance of the Canadian nuclear power industry (see subsection 7.2 (iii) c). The complete definitions of each rating category, a listing of the safety areas and programs, and the rating results from the annual safety reports produced during the reporting period are provided in Appendix G.

Action #5 on Canada from the Third Review Meeting of the Convention was to improve the rating system used to evaluate licensee performance. During the reporting period, CNSC staff received additional detailed guidance related to use of the existing rating system for evaluating NPP licensees. Progress was made toward considering all applicable data and achieving objectivity and consistency (for the different licensed sites, from one rating period to the next and from one safety area to the next).

During the reporting period, CNSC staff clarified some of the requirements and expectations against which licensee programs are rated. For example, references to regulatory standards for reliability programs and probabilistic safety assessments (see subsection 14 (i) d) were added to operating licences. CNSC staff also defined broad performance objectives for each of the safety areas and programs, which are listed in Table G.2 in Appendix G. In the *Annual CNSC Staff Report for 2006 on the Safety Performance of the Canadian Nuclear Power Industry*, CNSC staff rated the implementation of licensee safety areas and programs against these performance objectives.

During the reporting period, the licences to operate Bruce A, Bruce B, Pickering A, and Point Lepreau were renewed for five years. The licence to operate Gentilly-2 was renewed for four years.

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

Licence Amendments

The Commission can amend an NPP operating licence to modify existing licence conditions, add new licensing requirements, or to approve revisions to licensee documents referenced in the licence. Examples of such documents include operating policies and principles (OP&P), station shift complement, radiation protection requirements, and emergency plans.

7.2 (iii) Regulatory Inspection and Assessment

7.2 (iii) a General Description of Compliance Program

As stated in subsection 7.2 (ii) a, 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.

Section 30 of the NSCA authorizes CNSC staff to carry out inspections in order to verify licensee compliance with regulatory requirements, including any licence conditions. Licensees are expected to have a set of programs and processes in place to adequately protect the environment and the health and safety of workers and the public (a representative list of licensee programs is included as Appendix C).

The CNSC regulatory policy *Compliance* (P-211) is implemented through a corporate-wide compliance program, which integrates all compliance elements and whose output is integral to the operating licence renewal process (see subsection 7.2 (ii) e). This program consists of three elements:

- promotion to encourage compliance;
- verification activities to confirm that licensees are complying with safety provisions; and
- reactive control measures to enforce compliance.

7.2 (iii) b Promotion of Compliance

Promotion of compliance refers to all activities related to fostering conformity with legal requirements. The goal is to maximize compliance by strengthening those factors that encourage it and by mitigating those that hinder it. Compliance promotion can take the form of consultation; acknowledgement of good performance; collaboration with other regulatory bodies; as well as dissemination of information to the regulated community about regulatory requirements, and the standards and the rationale behind them. Specific compliance promotion activities include training, seminars, workshops, and conferences.

7.2 (iii) c Verification of Compliance

General

Verification includes all 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; and
- desktop reviews, which include reviewing documents such as the licensee's safety reports, event reports, etc. (see subsection 7.2 (iii) b for more examples); determining the safety significance of any findings; and identifying possible follow-up activities.

Inspections typically include interviews with responsible licensee staff; review of documentation, data, logs, and related events; and field component line-up checks. Some inspections monitor licensee activities as they unfold; for example, exercises or outages.

Acceptance criteria that can be used to assess compliance may be derived from one or more of the following:

- legal requirements;
- CNSC regulatory documents that clarify how the Commission intends to apply the legal requirements;
- information supplied by licensees to the Commission that defines how licensees intend to meet legal requirements in performing the licensed activity; or
- CNSC staff's expert judgement, including knowledge of best-industry practices.

Programs evaluated are those included in the licensing process (see Appendix C). In verifying that licensees abide by their programs, the CNSC will check that the licensee's activities meet CNSC acceptance criteria defined during the licensing process. Other licensee programs, processes, areas, and systems that are typically covered in compliance verification activities are listed in a table in subsection 7.2 (iii) c.

Inspections

A CNSC procedure for conducting Type I Inspections was introduced in 2004. Type I Inspections are always 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 could include specialists from head office, inspectors-from the site office or a combination of the two. The licensee is notified in advance of the inspection and its subject area, and entrance meetings, daily briefings of results and exit meetings are included in inspection plans. The results are recorded in a CNSC report to the licensee, and follow-up actions are documented and assigned target completion dates.

Resident CNSC inspectors typically perform Type II Inspections according to inspection guides. Except in the case of system inspections, results are not normally transmitted formally to the licensee by letter.

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

To help achieve regulatory effectiveness, efficiency, consistency, and clarity, the CNSC compliance program uses a planned set of baseline inspections. The baseline set was established by identifying a group of Type I and II Inspections for a typical plant and operations (for example, for those programs and areas listed in Appendix C and the table in Annex 7.2 (iii) c). Inspections were then assigned to the CNSC safety areas and programs (refer to Appendix G). The baseline set was subsequently refined to represent a reasonable set of inspections for a licensee having acceptable ratings in the safety areas during the preceding period.

The baseline set of inspections is delivered over a schedule of five years, the typical licence duration for Canadian NPPs. For safety areas where the licensee does not meet acceptable compliance and safety standards, risk management principles are used to identify focused activities that CNSC staff will undertake in the next period to supplement the baseline inspections. Monitoring includes the quarterly review of results of all verification activities. The baseline program can be considered as a risk-informed performance-based measure and hence a notable step toward addressing action #8 on Canada from the Third Review Meeting of the Convention.

Event Reporting, Follow-up, Recording and Tracking

CNSC staff review safety-significant events that have occurred at NPPs. The reviews do not aim to duplicate reviews done 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 regulatory standard *Reporting Requirements for Operating Nuclear Power Plants* (S-99) went into effect on April 1, 2003, replacing a previous standard. The new standard was required because the legislative framework had changed with the coming into force of the NSCA. S-99 consolidates almost all legislated reporting requirements contained in the NSCA and its associated regulations that apply to NPPs. The new standard also expands upon legislated general reporting requirements relating to NPPs. S-99 was incorporated into the operating licences of all NPPs in 2003, making compliance with the document mandatory. The CNSC offered numerous interpretations to several clauses of S-99 to ensure consistency of reporting.

The types of reports required by S-99 are listed in Annex 7.2 (iii) c.

Preliminary reports for the most serious 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.

At every public Commission meeting, CNSC staff present “Significant Development Reports” (SDRs) on safety-significant issues that may arise during or as a result of the conduct of any regulated activity and on any other matter of interest to the CNSC or to the public. CMD 03-M68 includes established guiding criteria for CNSC staff to use when selecting issues to include in SDRs.

Performance Indicators

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

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

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

Significance Determination

Significance determination is an important part of the compliance program. The CNSC uses significance determination to select the appropriate regulatory response to events. Progress has been made in using a consistent approach to assess the safety significance of inspection findings. Criteria and procedures for significance determination are evolving at the CNSC, using both deterministic and risk-informed methodologies.

Summation

The CNSC prepares an annual staff report on the safety performance of all Canadian NPPs. The *Report on the Safety Performance of the Canadian Nuclear Power Industry* integrates information gathered through CNSC staff verification activities of the NPPs and uses the rating system described in subsection 7.2 (ii) e to summarize the assessments of the programs and safety areas for each NPP. The document makes comparisons where possible, shows trends and averages, and highlights significant issues that pertain to the industry at large. It addresses the subject areas evaluated in the licence renewal process and uses CNSC performance indicators to compare NPPs.

During the reporting period, CNSC requirements were effectively met or exceeded in the majority of safety areas for all NPPs (see Appendix G).

7.2 (iv) Enforcement

Enforcement includes all activities to compel a licensee into compliance and to deter non-compliance with legal requirements. Enforcement is applied using a graduated approach, where severity of the enforcement measure depends on the safety significance of the non-compliance and other related factors. Graduated enforcement tools include the following:

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

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

Examples of licensing activities are as follows:

- Short-term licence or extension: If the CNSC is not satisfied that a licensee has the required commitment to safety, as indicated by the current compliance history, CNSC staff may recommend that the Commission grant a licence for a shorter term. Alternatively, the Commission may grant a short-term extension to allow the licensee sufficient time to make required improvements 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; and
  - a requirement to appear before the Commission on a regular basis to provide status reports on progress in improvements to operation and maintenance programs.
- Licence suspension or revocation: CNSC staff may recommend to the Commission that it 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; and
- 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 make an 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. The NSCA gives the Commission the authority to make any order without prior notice, where necessary to do so in the interests of health, safety or security. Where warranted, prosecution is also an option. The following are some examples of specific instances of non-compliance, the severity of which might lead to prosecution:

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

A Generic Action Item (GAI) is a verification/enforcement tool specific to NPPs and is discussed in detail in subsection 14 (i) b.

Article 8 – Regulatory Body

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

8.1 Establishment of the Regulatory Body

8.1 a General

The Canadian Nuclear Safety Commission (CNSC) is the nuclear regulatory body in Canada, established by the *Nuclear Safety and Control Act* (NSCA). The fulfillment of its mandate (see subsection 7.1 b) is accomplished by the work of the Commission, a quasi judicial administrative tribunal comprised of a maximum of seven members. 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 of the Commission and the Chief Executive Officer of the CNSC as an organization.

In keeping with federal policies on public consultation and regulatory fairness, the CNSC consults with 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;
- special interest groups; and
- groups or individual members of the public.

CNSC public hearings are the public’s primary opportunity to participate in the regulatory process. CNSC staff attends these hearings, as necessary, to advise the Commission. Subsection 17(1) of the NSCA stipulates that the Commission can also hire external staff members to advise it, independently of CNSC staff, although this is not currently being done.

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

8.1 b Position and Funding of the CNSC Within the Government Structure

The CNSC is a departmental corporation, listed in Schedules II and V of the *Financial Administration Act.* The NSCA stipulates that the CNSC shall report to the Parliament of Canada through a member of the Privy Council for Canada (Cabinet) designated by the Governor in Council as the Minister for purposes of the NSCA. Currently, this designate is the Minister of Natural Resources Canada (NRCan). The Commission requires the involvement and support of the Minister for special initiatives, such as amendments to regulations and requests for funding.

The CNSC's operations are funded through annual appropriations from Parliament. Most costs incurred for CNSC regulatory activities are recovered by the Government of Canada from licensees under the *CNSC Cost Recovery Fees Regulations*. The CNSC collects fees and deposits them into the Consolidated Revenue Fund of the Government of Canada. Fees are not charged for activities that the CNSC is obliged to conduct and that have no direct benefit for individual licensees (for example, activities related to non-proliferation, emergency preparedness, public information programs, and maintaining the NSCA and its associated regulations). When its workload increases, the CNSC applies to the Government of Canada's Treasury Board Secretariat to increase its cost-recoverable expenditures and related fee revenues accordingly, and/or to receive new program funding. For example, the Treasury Board Secretariat granted additional funds during the reporting period for the CNSC to hire new staff in order to support anticipated regulatory work related to life extension projects and applications for new NPPs.

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

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

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

In addition to private-sector organizations (such as Bruce Power), CNSC licensees include the following publicly owned institutions or agents of the federal and provincial governments:

- AECL (the federal nuclear research and development company);
- NRCan;
- nuclear operations of provincially owned electrical utilities Ontario Power Generation, New Brunswick Power Nuclear and Hydro-Québec;
- Canadian universities;
- hospitals and research institutions; and
- federal and provincial government departments.

8.1 c Organization and Support of CNSC Staff

The CNSC consists of a President, the federally appointed Members of the Commission, and approximately 600 staff members as of the end of March 2007. The organization's general structure is defined by the NSCA. Subsection 12(1) of the NSCA states that the President "has supervision over and direction of the work of the Commission, and of the officers, technical and otherwise, employed for the purpose of carrying on the work of the Commission."

The President's Office provides administrative support services directly to the President. The Secretariat ensures that the seven-member Commission has the administrative and technical support it needs to function efficiently and effectively. Other groups in the CNSC organizational structure that support the President include the Quality Council; the Legal Services Unit; the Office of Audit, Evaluation and Ethics; and the International Relations Group.

The CNSC has three major branches: Operations, Regulatory Affairs and Corporate Services.

Operations Branch

The Operations Branch is responsible for regulating the development, production and use of nuclear energy, as well as the production, possession, transport and use of nuclear substances and radiation devices in accordance with the requirements of the NSCA and its regulations. The Operations Branch is organized to focus on the regulation of different sectors of the nuclear industry and to support implementation of consistent regulatory and business processes. The management hierarchy and mandates of the directorates in the Branch establish accountability and authority for leadership of regulatory activities. As of the end of the reporting period, a new structure has been announced consisting of two branches: the Regulatory Operations Branch and the Technical Support Branch. These will be instituted in 2007.

The Operations Branch is headed by an Executive Vice-President and is comprised of the following:

- Directorate of Power Reactor Regulation;
- Directorate of Nuclear Cycle and Facilities Regulation;
- Directorate of Nuclear Substance Regulation;
- Directorate of Assessment and Analysis;
- Directorate of Safety Management and Standards;
- Directorate of Security and Safeguards;
- Directorate of Environmental and Radiation Protection and Assessment; and
- Regulatory Program Improvement Division.

The Directorate of Power Reactor Regulation (DPRR) evaluates and regulates the safety of NPPs in Canada through its regulatory program. The Directorate consists of the following divisions:

- four regulatory program divisions (for Pickering, Darlington, Gentilly-2/Point Lepreau and Bruce);
- the Inspection Division;
- the New Reactor Licensing Division; and
- the Program Development and Integration Division.

The Darlington, Pickering, Bruce and Gentilly-2/Point Lepreau regulatory program divisions were established in the DPRR in 2005, following a realignment of the Operations Branch, which moved the specialist divisions to other directorates within the branch. These four regulatory program divisions are accountable for the planning, management and implementation of the regulatory program relative to their respective NPPs. They also act as a single point of contact for internal and external stakeholders.

The DPRR’s Inspection Division is accountable for delivering the inspection program in a coordinated and consistent manner at all NPP sites. Permanent CNSC staff members work at each site to implement CNSC compliance program activities (promotion, verification and enforcement) .These staff members inspect licensee premises, monitor activities and ensure compliance with licences and governing documents.

The New Reactor Licensing Division in the DPRR was created in 2006 to ensure the CNSC has dedicated staff and proper leadership for the planning, management and assessment of new reactor licence applications. This division will lead the development of the regulatory framework as well as develop a plan for assessing licence applications for new reactors.

The Program Development and Integration Division is responsible for developing and implementing DPRR programs for licensing; evaluating compliance with regulatory requirements and standards; documenting results of regulatory activities; and integrating and monitoring trends of compliance information for NPPs in accordance with Operations Branch procedures.

Staff in other directorates in the Operations Branch support the regulatory activities led by the DPRR; for example, by reviewing NPP licensee submissions, participating in inspections, and helping to develop relevant regulatory documents.

Regulatory Affairs and Corporate Services Branches

The newly created Regulatory Affairs Branch is headed by a Vice-President and provides strategic direction and implementation of the CNSC's regulatory policy, planning and communications areas. It encompasses the Office of Communications and Regulatory Affairs and the Corporate Planning and Performance Management Division. The Office of Communications and Regulatory Affairs provides CNSC staff and the public with accurate and timely information on CNSC programs and activities and is responsible for several organization-wide programs, initiatives and actions that aim to enhance the CNSC's regulatory performance . The Corporate Planning and Performance Management Division is responsible for leading the development and implementation of integrated planning at the CNSC.

The Corporate Services Branch provides general services necessary for the functioning of the Operations Branch and other parts of the CNSC.

Planning Process for Regulatory Activities

The CNSC organizes its regulatory activities for NPPs (described in Section 7.2) 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 (RAP), which is costed to establish an estimate of the annual licence fee for each NPP. The RAP, along with a notification containing the licence fee estimate, is sent to each licensee in advance of each fiscal year.

CNSC Research and Support Program

The CNSC Research and Support Program continues to provide staff with access to independent advice; expertise, experience, information and other resources, via contracts or contribution agreements placed with the private sector as well as other agencies and organizations in Canada and internationally. The work undertaken through the Research and Support Program is intended to support staff in meeting the CNSC's regulatory mission. Each year, the program is reviewed and evaluated, the need for research and support in the following year is identified, and a commensurate budget is allotted. The CNSC Research and Support Program is independent of the extensive R&D program conducted by the industry (see Appendix E).

Where the CNSC requires special expertise, it also obtains services from external sources. The Research and Support program provides access to independent advice, expertise, experience, information and other resources via contracts placed in the private sector and with other agencies and organizations in Canada as well as in other countries.

8.1 d Improvement Initiatives and Assessment of the Regulatory Body

Continuing improvements in the CNSC regulatory regime aim to establish a power reactor regulatory program that is risk-informed, cohesive, consistent, systematic, effective and efficient, by:

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

Action #6 on Canada from the Third Review Meeting of the Convention was to finalize the PRRIP. Some of the accomplishments in the PRRIP during the reporting period included developing a protocol for CNSC communications with NPP licensees and a refined process for planning NPP regulatory activities. Another PRRIP accomplishment — the development of a risk-informed decision-making process (see below) — is directly related to Action #8 on Canada from the Third Review Meeting of the Convention to enhance the risk-informed, performance-based approach.

The initiatives under PRRIP that were not completed were incorporated into a broader improvement initiative (see description of I3P below).

Risk-Informed Decision Making (RIDM)

Although the regulatory framework and decision making for NPP regulation in Canada have always considered risk, the methods used to address risk systematically were not formalized. CNSC staff formed a working group in 2005 to enhance the CNSC's regulatory capacity with respect to the following:

- assessment of risks associated with NPPs and the use of risk management principles to prioritize regulation and regulatory changes, so that the CNSC's limited resources are used as effectively as possible; and
- planning of regulatory activities based on risk analysis; results of previous regulatory activities; a rigorous and well-documented process linking activities to required results; and staff judgement and expertise.

To meet these objectives, the working group identified appropriate risk management tools and methods, organized discussion and training sessions, interacted with stakeholders, and produced documents that defined "risk management" in the CNSC's regulatory context. The group also described basic concepts of risk and risk management, highlighted typical risk decision-making situations at the CNSC, and outlined a decision-making process, based on CSA-Q850, for managing risk.

This new decision-making process was introduced in May 2006, for a 12-month trial period that included one-day training sessions and limited applications of the method. The first application of this process was in the context of formulating a regulatory response to a licensee proposal pertaining to power reactor trip coverage. A CNSC team followed the steps of the process, which include initiating the process; performing an initial analysis and identifying potential hazards; estimating risk; evaluating the risk activity; controlling the risk; taking action; and monitoring the impact. The team identified the issue, developed eight risk scenarios, and ranked them in terms of risk (very high, high, medium, or low). In the "controlling the risk" step of the process, the team developed appropriate provisions to address the risk. For example, for the high-risk scenarios, the licensee was requested to provide substantiating analyses and new experimental data in addition to administrative controls, in order to bring the risk closer to the acceptable range. The remainder of the process has been suspended pending the licensee's response to the proposed controlling measures.

The CNSC has also applied the RIDM process to an ongoing project to establish and prioritize a comprehensive list of generic CANDU safety issues (see subsection 14 (i) b for details).

Management System

In 2005, the CNSC formally committed to establishing a corporate-wide management system in accordance with the requirements and guidance in IAEA Safety Standard *Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety* (GS-R-1), draft standard *Management Systems for Regulatory Bodies* (DS-113), and accompanying safety guides. Furthermore, the CNSC established a Quality Council headed by the Chief Quality Officer, a position held by the Executive Vice President of Operations. A new division for internal quality management was also formed.

The purpose of the management system is to define and apply a common set of practices, principles and processes across the CNSC. The management system will provide the CNSC with an overarching and uniform management structure by:

- bringing together, in a coherent and consistent manner, all the business requirements for the organization to deliver effectively on its mandate;
- mapping out and managing processes as part of a larger integrated system to minimize duplication;
- defining roles, responsibilities and authorities;
- defining processes and procedures that relate to activities as opposed to general functional roles; and
- serving as a consistent framework for continual and ongoing improvements.

In 2007, CNSC staff is planning to issue a revised management system manual to address action #4 on Canada from the Third Review Meeting of the Convention.

Preparations for the Integrated Regulatory Review Services Mission

Following the Third Review Meeting, the CNSC established a project to host a mission from the IAEA's Integrated Regulatory Review Services (IRRS). A letter that officially requested such a mission was sent to the IAEA in November 2005. The project is being planned and executed in accordance with relevant IAEA documents and will follow the IAEA's modular IRRS approach.

As part of the CNSC's preparation for the IRRS mission, a self-assessment review team (SART) conducted an assessment in 2006 that outlined recommendations and suggestions for improvements at the CNSC. The following five corporate-wide improvement projects were initiated in response to the recommendations in the SART report:

1. management system;
2. integrated planning and performance management;
3. regulatory compliance processes;
4. regulatory licensing processes; and
5. leadership development.

A corrective action plan was drafted during the reporting period to respond to the SART's recommendations and suggestions and to establish an integrated plan to implement the five improvement projects. The incomplete initiatives under the PRRIP were also incorporated in the corrective action plan. The licensing and compliance improvement initiatives aim to develop and implement integrated solutions, which will improve the timeliness and visibility of licensing and compliance decisions; and increase the clarity of roles, responsibilities, authorities, and accountabilities for licensing and compliance activities. The current processes for licensing and compliance are described in Article 7.2.

In 2006, a structure called the Integrated Improvement Initiatives Program was created to enhance integration among all five of the aforementioned corporate-wide improvement projects. The management system was identified as the lead initiative.

Since the original request to the IAEA, the scope of the IRRS mission has expanded to include uranium mines and mills and nuclear substances. Subject to discussions between the CNSC and IAEA, the IRRS peer review is planned for the next reporting period. Completion of the mission will address action #11 on Canada from the Third Review Meeting of the Convention.

8.1 e Maintaining Competent Staff

Recruitment and retention of staff has been a key strategic objective of the CNSC for several years. Historically, the CNSC has recruited experienced personnel from universities and industry. However, the CNSC is addressing the same human resources issues faced by licensees as well as research and development organizations (see subsection 11.2 b). The Third Review Meeting's action #3 on Canada (to maintain safety competence) was therefore directed to the CNSC as well as to the NPP industry.

Between the years 2001 and 2005, 26 highly qualified university graduates were part of the CNSC's Internship Program, which has provided the CNSC with a group of excellent new scientific and technical staff. In early 2005, the CNSC completed a scan of demands for the next 10 years. It was determined that, to meet future needs, the CNSC would have to adopt new recruitment approach and ensure the integration of new staff. The CNSC will be drawing on the best practices of the Internship Program in developing future recruitment and orientation strategies.

Currently, the CNSC is conducting a recruitment and retention initiative that is built on five pillars:
- internal assessment;
- general recruitment;
- international recruitment;
- university partnerships; and
- employee retention.

An international recruitment campaign targeting France, Germany, Sweden and the United Kingdom was launched in 2006. Also in 2006, 80 Canadian universities were contacted to explore areas of mutual interest. In an attempt to enhance the CNSC's profile on Canadian university campuses, 13 information sessions targeting students in engineering, science and environmental studies were then conducted.

The CNSC Employee Orientation Program was reviewed during 2006 and is being updated. A series of consultations with a task force comprised of representatives from throughout the CNSC provided input on several of the recruitment and retention pillars. These consultations also addressed the integration of new and recent graduates into the organization.

The CNSC is developing and/or co-ordinating programs for learning and training. Staff and managers are expected to work together to develop individual learning plans using available tools. The CNSC has also continued contributing to the CANTEACH and University Network of Excellence in Nuclear Engineering programs (see subsection 11.2 b for details).

8.2 Supporting the Separation of Roles

8.2 a Separation of CNSC and Organizations that Promote and Utilize Nuclear Energy

The passage of the NSCA created distinct, enabling legislation for the regulation of nuclear activities and the separation of functions of the regulatory body from organizations that promote or use nuclear energy.

The mandate of the CNSC (see subsection 7.1 b) focuses clearly on the health and safety of persons and the protection of the environment, and does not extend to economic matters.

Section 19 of the NSCA authorizes “the Governor in Council [to], by order, issue to the Commission directives of general application on broad policy matters with respect to the objects of the Commission.” However, any political directives given to agencies — such as the CNSC in this case — must be of a general nature and cannot fetter the Commission’s decision-making authority in specific cases. In addition, such an order would be published in the *Canada Gazette* and laid before each House of Parliament.

As mentioned in subsection 8.1 c, the CNSC maintains permanent staff from its Inspection Division at the NPPs to deliver inspections, compliance promotion, and enforcement activities that fall under the regulatory activity plan. The regulatory program divisions make decisions related to regulatory activities and make recommendations for decisions by the Commission. 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 has limited interaction with the Commission outside of hearings.

8.2 b Strategic Communications

Part of the CNSC’s mandate is to disseminate information to all stakeholders (see subsection 7.1 b). The CNSC has ongoing, transparent discussions with the Canadian Nuclear Association (via a Regulatory Affairs Committee since the year 2000) and with NPP and other licensees (via the Cost Recovery Advisory Group since 2002). The CNSC strategic communications plan, which was finalized during the reporting period, describes an approach for the CNSC to effectively communicate its regulatory program to stakeholders.

The CNSC strategic communications plan involves a three-year phased approach. During 2006 and 2007, the CNSC focused its outreach activities on heightening public awareness and understanding of its role and of regulated nuclear activities. In 2006, there was enhanced engagement with diverse stakeholders, which included municipal governments in the regions of major facilities, media, provincial officials, professional associations and non-governmental organizations (NGOs).

In late 2006, the CNSC established a Non-Governmental Organization Regulatory Affairs Committee to communicate and consult with NGOs on nuclear regulatory and policy matters within its mandate. Given that a similar industry-based forum had existed since 2001, this Committee was established to allow the CNSC to expand its engagement with stakeholders. Co-chaired by a member of the NGO community, the Non-Governmental Organization Regulatory Affairs Committee is a forum for exchanging and clarifying information to promote common understanding of issues. It allows the CNSC to better respond to the information needs of the NGO community, while enabling NGO members to provide input and advice to the CNSC on broader issues related to nuclear regulation in Canada. In addition to this forum, the CNSC also established links in early 2007 with an association of host communities of major nuclear facilities.

The CNSC has held numerous hearings in communities most affected by the Commission’s work. To ensure the needs of future stakeholders are met, the CNSC is proactively contacting communities likely to become involved in nuclear activities, such as mining and milling, throughout the next decade. Finally, in 2007, the CNSC plans to hold five information sessions in communities across Canada to present information on its annual staff assessment of the safety performance of NPPs.

8.2 c Values and Ethics

In 2005, the CNSC formally launched a Values and Ethics Strategy and an internal disclosure function to strengthen the organization's ethical climate, governance, leadership and operational activities. As Canadians are increasingly interested in values and ethics and the disclosure of wrongdoing in the public sector, legislative requirements were introduced by the Government of Canada in 2006. The *Federal Accountability Act* was created with the aim of creating "an environment in which employees and all Canadians can honestly and openly report wrongdoing in the federal government without fear of reprisal."

The *Public Servants Disclosure Protection Act* was expected to come into force in April 2007. The purpose of the law is to encourage public-sector employees to come forward if they have reason to believe that serious wrongdoing has occurred in the workplace. It protects employees who do come forward from reprisal and also provides a fair, objective process for those accused of wrongdoing. The CNSC plans to implement the law in the next reporting period, using an approved strategy that will complement its other internal disclosure mechanisms

The aforementioned tactics aim to facilitate proper conduct of CNSC operations without undue influence from forces and concerns falling outside the organization's mandate.

Article 9 - Responsibility of the Licensees

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.

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) a, the Commission can only issue licences to applicants that are qualified to operate the NPP and will adequately provide for the health and safety of persons and the protection of the environment.

Paragraph 12(1)(c) of the *General Nuclear Safety and Control Regulations* assigns various responsibilities to the licensees, including the following general responsibility:

"Every licensee shall…take all reasonable precautions to protect the environment and the health and safety of persons…"

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."

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

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

When working to set requirements and assure compliance (see first item in the preceding list), the CNSC:

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

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

The CNSC produces only general performance standards for NPPs. Licensees are responsible for translating these standards into detailed criteria in order to develop systems, programs and designs that satisfy CNSC standards. Descriptions of design provisions are submitted to the CNSC at the time of licence application. Examples of these provisions include the design of safety-related systems; the overall safety policy (see Article 10); operating policies and principles (OP&P); and program descriptions (see Appendix C).

If the CNSC approves the design provisions, they become part of the licensing basis for an NPP and dictate future regulatory activities, such as inspections and change approvals. The CNSC also monitors licensee compliance and performance against design provisions written into NPP operating licences.

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

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

- implementing managed systems to control risks associated with NPP operations;
- developing an organizational culture committed to ensuring safe NPP operation;
- defining safe operating limits and working within them;
- monitoring both employee and facility performance to ensure expectations are met; and
- ensuring that adequate resources and facilities are always available to respond to planned activities and contingencies.

Information submitted in support of a licence application may be referenced in licence conditions, thus creating a legally enforceable operating requirement (as exemplified in the OP&P document). For each NPP, the OP&P document explains how licensees shall operate, maintain and modify systems to maximize nuclear safety and keep consequential public risk acceptably low. This document also defines the authority and responsibilities of managers and operating staff (see Sections 19 (ii) and 19 (iii) for details on OP&Ps). The CNSC must approve the initial OP&P document along with the application for an operating licence, as well as all OP&P changes proposed by the licensee at any time. As with other documents referenced in an operating licence, failure of licensee staff to follow OP&P requirements represents a breach of the licence and must be reported to the CNSC.

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 Nuclear Power Plants* (S-99), which establishes reporting requirements for safety-significant developments and non-compliance with legal requirements. (subsection 7.2 (iii) c contains details on S-99.) Licences also make reference to licensee-produced documents (for example, OP&Ps).

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

PART C
General Safety Considerations

Part C of Chapter IV consists of seven articles:

Article 10 – Priority to Safety
Article 11 – Financial and Human Resources
Article 12 – Human Factors
Article 13 – Quality Assurance
Article 14 – Assessment and Verification of Safety
Article 15 – Radiation Protection
Article 16 – Emergency Preparedness

Article 10 – Priority to Safety

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

10 a Establishment of Policies 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.

This priority has not been explicitly stated as a regulatory requirement of NPP licensees in Canada. Currently, CNSC licences reference the "old" CSA-N286 series on quality assurance (QA) that requires a high-level policy statement committing all levels of the organization to a QA program (see section 13 a). However, as stated in the last subsection of Article 13 c, licensees, AECL and the CNSC participated in the development of a CSA standard on *Management System Requirements for Nuclear Power Plants* (N286-05). A primary purpose of the new standard is to promote safe and reliable operation of NPPs via a commitment and adherence to a set of management system principles. All licensees have implemented the principles in their management systems and have established policies that give due priority to nuclear safety. Implementation of the principles in the policies and processes differs by licensee, as described in Annex 10 a. The CNSC reviews these management systems prior to issuing licences to ensure they adequately support the applicant's provisions to protect health and safety. The QA program (see Article 13) provides assurance that policies, principles and high-level safety requirements are carried through adequately to licensee activities.

10 b Safety Culture

General Approach to Operational Safety Culture

The general approach to operational safety culture is best described using the example of New Brunswick Power Nuclear (NBPN). The safety culture at NPBN 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 NBPN safety culture is further established by constantly examining nuclear safety; cultivating a “what if?” approach; embracing organizational learning; and allowing trust to permeate through the organization. All employees are expected to be aware of, and to adhere to, all rules, policies and regulations related to nuclear safety, radiation safety, industrial safety, and fire protection. These expectations are promoted through training and leading by example; monitored through field observations and self-assessments; and assured by means of the Problem Identification and Corrective Action system and coaching.

From a licensee perspective, enhancing safety culture is interconnected with three “improvement focus areas”: plant material condition, work planning, and human performance. These areas are all relevant to licensees’ quality management programs. For example, operating with plant material in a degraded condition can lead to complacency regarding NPP safety. Similarly, inefficient work planning processes perpetuate the degraded condition of plant material and can result in personnel frustration and inattention to detail. Inadequate human performance also results in more challenges to work planning processes and degraded condition of plant material. Licensees’ improvement efforts therefore focus on each of these three areas (plant material condition, work planning and human performance) in order to strengthen all aspects of NPP operation.

Licensees are also developing programs to enhance safety culture on an ongoing basis. These programs focus on providing staff members with an understanding of their roles in improving safety and where their organizations are heading in terms of short- and long-term performance. Licensees are also cooperating in the development of leading indicators to signal weaknesses in safety culture.

CNSC Activities Related to Safety Culture Assessment

CNSC staff uses the Organization and Management Review Method, which is an objective and systematic approach, to evaluate licensees’ organizational influence on safety performance (see subsection 3.10.2 of the third Canadian Report for details). This method has been used extensively at one NPP to conduct baseline assessments of the organizational processes at all NPPs in Canada. A follow-up assessment was conducted to obtain comparative data, in order to determine where subsequent improvements were made and whether performance declined. The CNSC plans to continue using this method to assess safety performance at all NPPs at least once every licensing period.

In 2004 and 2005, the CNSC arranged safety culture workshops for a representative group of licensees, where they discussed the outcomes of a Safety Culture Symposium held in 2004. The licensees shared information on their safety management programs and provided input to the CNSC on its draft document *Guidance for Safety Culture Self-assessment of Licensee Facilities* that they used to develop self-assessment methods.

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

Safety Culture Self-Assessments at Ontario Power Generation

Ontario Power Generation (OPG), along with other Canadian NPP licensees, has been developing a safety culture self-assessment process that closely parallels a process developed by Utilities Service Alliance Inc.

The first round of five nuclear safety culture self-assessments were completed at Pickering A and B, as well as Darlington during the reporting period. Strengths identified in the assessments include the following:

- employee concerns: requirements for reporting incidents and concerns are well understood; employees feel encouraged to voice concerns without fear of retribution;
- nuclear safety oversight: management oversight of nuclear safety-related activities is appropriate; meetings with respect to operational decision-making and challenges are cited as effective tools;
- roles and responsibilities: those relating to personal safety are clear;
- safety-critical decision making: chain of command and control is clearly understood in the operations department;
- operational decision-making process is seen as thorough and rigorous; and
- regulatory relationships: perceived to be open and mutually respectful; relationships with federal and provincial regulators.

Areas for improvement identified across the OPG's three NPPs include the following:

- communication and trust: perceived to be one way with inadequate personal contact between management and employees;
- corrective action: belief that feedback process is lacking; low confidence that repeat events could be avoided;
- recognition and rewards: opinion that performance is recognized over safety; and
- work management: excessive length of time sometimes taken to correct problems.

OPG has introduced focused initiatives to address these areas.

The nuclear safety culture framework and self-assessment methodology, tools and process continue to be refined based on lessons learned from the OPG assessments and the continuing development of the Utilities Service Alliance safety culture assessment process.

<u>Safety Culture Self-Assessments at Hydro-Québec</u>

Hydro-Québec conducted a safety culture self-assessment at Gentilly-2 in 2004 with support from the Utilities Service Alliance. The results of the self-assessment were applied to a safety culture framework created by CANDU Owners Group (COG).

The purpose of the evaluation was to provide insight and to motivate change for improvement. It identified good practices and strengths, observations that need to be reviewed and characterized, and areas for improvement. At the subsequent safety culture self-assessment at Gentilly-2 in early 2007, visible improvements in housekeeping, equipment condition, and the increased use of external assistance were noted. The assessment was carried out in two stages: an all-staff survey, and on-site interviews and observations. The survey results indicated a healthy response under the category "respect for safety."

<u>Safety Culture Self-Assessments at Bruce Power</u>

Since its inception in 2001 Bruce Power has carried out two safety culture self-assessments: one in 2001 and one in 2005. These assessments involved observing the behaviour of the organization over a one-week time span and comparing the observations against a series of defined safety culture characteristics. The assessment teams were composed of internal personnel, personnel from other Canadian facilities and outsourced experts in the area of safety culture. These self-assessments showed that Bruce Power has a culture of openly reporting issues and incidents. Weaknesses were noted in communicating expectations and enforcing standards. Bruce Power is taking corrective actions to ensure that management reinforces expectations and standards. Bruce Power intends to perform a self-assessment of its safety culture every three to five years.

Safety Culture Self-Assessments at Atomic Energy of Canada Limited

Safety culture workshops are held on an ongoing basis to create a common understanding of safety culture across the organization. During these workshops, discussions are held on several aspects of safety culture, identifying examples applicable to the specific groups in attendance; and action plans are established with tangible steps to address the issues within specific timelines. Self-assessment on specific topics is performed on an ongoing basis.

Article 11 - Financial and Human Resources

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

11.1 Adequacy of Financial Resources

11.1 a Financing of Safety Improvements Made to Nuclear Power Plants During Their Operating Life

The 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 (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

NPP licensees in Canada are required by licence conditions, imposed pursuant to subsection 24(5) of the NSCA, to provide financial guarantees for the costs of decommissioning NPPs. Preliminary decommissioning plans are also included as operating licence conditions. Canada's four NPP licensees have opted for different methods of supplying decommissioning financial guarantees, as allowed by CNSC regulatory guide *Financial Guarantees for the Decommissioning of Licensed Activities* (G-206). In all four cases, the financial guarantee arrangements include a legal agreement granting the CNSC access to the guaranteed funds in the event of default by the licensee, as well as licence conditions that require the licensee to revise the decommissioning plans, cost estimates and financial guarantees periodically or as required by the regulator. 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*.

11.1 c Financial Resources for Operations

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. As an example, Bruce Power operates the Bruce A and B NPPs but it is not the owner or the responsible party for the final decommissioning of these facilities. This responsibility rests with the owner, OPG, and as such, OPG is also responsible for the decommissioning financial guarantee for these facilities. Since Bruce Power is responsible for operating the facility, it was required to provide a unique financial guarantee to assure that funds would be available to put the NPPs into a safe storage state prior to decommissioning. This is not required from the other Canadian NPP licensees (Hydro-Québec, NBPN and OPG), as their decommissioning financial guarantees cover the full breadth of decommissioning, including the initial steps to place the facilities in a safe storage state. This financial guarantee would also cover the case if Bruce Power had to shut down for a prolonged period for reasons other than decommissioning, such as for unexpected repairs. The financial guarantee ensures that funds for safe shutdown are available if Bruce Power should ever find itself in financial difficulty under any of these circumstances.

11.2 Adequacy of Human Resources

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

11.2 a Requirements and Measures Related to Training and Certification of Workers

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

All multi-unit NPPs are required to have an authorized nuclear operator in direct attendance at each unit’s main control room panels at all times. The affected licensees committed in 2001 to meet this requirement by deadlines specified in their operating licences. Although each unit currently has an authorized nuclear operator on duty at all times, the panel may be monitored by a supervised control panel operator at certain times (such as meal breaks) under the supervision of an authorized nuclear operator at an adjacent panel.

Assessment of Licensee Training Programs

The CNSC regularly evaluates licensee training programs for certified and non-certified staff. Regulatory activities include review of training program material as well as on-site assessments and inspections of the training programs. CNSC staff also defines and establishes regulatory requirements and criteria for the training, examination and qualification of certified personnel at nuclear NPPs.

The training, examination and certification program is one of three programs within the “Performance Assurance” safety area (see Table G.2 in Appendix G). CNSC staff assigns grades for training, examination and certification based on the review of training programs, according to criteria founded on the “Systematic Approach to Training” (SAT) methodology — not on the performance of licensee candidates in certification exams. However, ongoing satisfactory certification of workers is a requirement for all stations.

During the reporting period, most stations received a “B” grade (“meets CNSC requirements”, as defined in Appendix G) for training, examination and certification. Notably, by 2006, significant improvements had occurred at Gentilly-2 in the implementation of SAT. The focus of the training evaluations at NPPs, during the reporting period, was on the transfer of certification examination as described in the next paragraph.

Transfer of Certification Examination of Licensee Personnel from the CNSC to Licensees

To improve regulatory effectiveness in the area of training and qualification of NPP operational personnel, the CNSC has decided to withdraw from the direct examination of reactor operators and shift supervisors. The CNSC plans to continue to certify these positions under its legal authority granted by the NSCA and the *Class I Nuclear Facilities Regulations,* based on the soundness of the training programs and on certification examinations set by licensees. The CNSC has drafted guidance documents that recommend practices for conducting these initial certification examinations. The CNSC is also gradually implementing inspections of the certification training and examination programs that are, or will be, administered by licensees.

11.2 b Capability Maintenance at NPP Sites

The nuclear industry in Canada expanded rapidly in the 1970s and 1980s. Much professional experience will be lost when many employees hired during that expansion period retire in the next few years. The industry needs to replace these workers, as well as increase staff numbers to address new projects. The new projects include both the refurbishment of NPPs built in the late 1970s and early 1980s to extend their lives 30 years into the future and the construction of new NPPs.

In 2004, the Canadian Electricity Association and Human Resources and Social Development Canada conducted a comprehensive HR study to:

- develop an industry profile of the Canadian electricity sector,
- determine root causes of identified human resources issues,
- identify best practices, and
- develop a vision and recommendations for an HR strategy.

The HR study identified the following key points for the electricity sector:

- Employment numbers declined from 98,725 in 1993 to 65,600 in 2003;
- Retirement is a serious and impending issue;
- Almost 40% of the workforce will be eligible for retirement by 2014;
- The sector needs to fill 9,000 vacancies over the next 5 years and 17,000 over the next 10 years;
- Sixty-five percent of the total electricity sector workforce is aged 40 to 54, compared to 38% of the national workforce;
- Less than 5% of employees are in the 15-to-24 age group, and 15% of the Canadian workforce is less than 25 years old;
- In trade-related occupations, 65% of employees are 50 years and older, whereas young employees (those under 30 years of age) represent only 7.1% of this segment; and
- Significant turnover in management is expected during the next 5 to 10 years.

Nuclear staff members are older than average, with 38.3% of technical staff 50 years or older.

The power sector is facing two challenges: over the next 20 years, the existing HR supply needs to be increased by an estimated 22%; and 20% of existing infrastructure in the electricity sector needs replacement. In Canada, an additional constraint is that the Oil Sands development and expansion in western Canada as well as gas pipeline construction projects may reduce available HR for the electricity sector.

A Canadian Nuclear Association symposium in September 2006 identified the HR issues facing the nuclear industry. It also pointed to specific steps to be taken in a multi-faceted strategy in order to meet the industry’s present and future human resources needs.

Changes in workforce demographics and the increasing industry requirements due to refurbishments and new construction require initiatives in four related areas:

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

The success of these programs in maintaining safety competence in the nuclear industry and at the CNSC is essential to addressing action #3 on Canada from the Third Review Meeting of the *Convention on Nuclear Safety*.

Workforce Capability Analyses

NPP licensees are conducting 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. Succession planning processes are in place at the NPP 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 (from "ready now" to "ready in one to two years" to "ready in three to five years") to assume a position are conducted. Development plans are put in place to prepare potential candidates to assume critical positions as employees retire.

AECL is addressing this issue through a comprehensive resource management system that focuses on engineering services to NPP licensees, refurbishment of existing reactors, and new reactors to be built. This centrally managed system covers various groups in AECL business units and takes an optimal approach to deal with volatility of business, balance customer needs, and ensure a consistent approach while complying with its collective agreement and using best practices. System elements are grouped based on supply, demand, resource planning, development of resources and performance management. Skills of individual technical staff are identified and maintained in a database, and succession planning specifically targets technical leaders and contractors. Attrition risk of these employees is identified as high, medium or low, with high risk typically covering senior staff members with specialized skills who are difficult to retain and train. Position descriptions are developed and used as the target for career development and training of staff.

Hiring Programs

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

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

At AECL, the supply of staff in the needed skills is maintained by internal postings and external hiring, including that of experienced staff on contract, such as retirees from AECL or the utilities. AECL recently hired a significant number of new graduates through on-campus interviews.

Training Programs

The University of Ontario Institute of Technology (UOIT) has shaped a nuclear engineering program to specifically meet industry needs. Industry members and the CNSC participate in formulating the curriculum through involvement in an advisory board to the university. The UOIT includes the School of Energy Engineering and Nuclear Science and offers undergraduate (bachelor) degrees and master's-level courses in nuclear engineering, radiation science and related areas. The program focuses on reactor kinetics, reactor design, plant design and simulation, radiation detection and measurement, radiation protection, radiation biophysics and dosimetry, environmental effects of radiation, production and utilization of radioisotopes, radiation chemistry and material analysis with radiation techniques. Similar engagement with colleges is 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 and NPP licensees, as well as research and regulatory agencies, to support and develop nuclear education and research and development capability in Canadian universities. The main objective of UNENE is to assure a sustainable supply of qualified nuclear engineers and scientists to meet the current and future needs of the Canadian nuclear industry, through university education, university-based training and the encouragement of young people to choose careers in the nuclear industry. The primary means of achieving this objective are to establish new nuclear professorships in six Ontario universities and to enhance funding for nuclear research in selected universities in order to retain and sustain nuclear capability in the universities. Through its member universities, UNENE organizes and delivers educational programs appropriate to students planning to enter the nuclear industry and to those already employed therein.

The CANTEACH program was established by AECL, OPG, COG, Bruce Power, McMaster University, l'École Polytechnique de Montréal and the Canadian Nuclear Society. Its aim is to develop a comprehensive set of Web-accessible education and training documents, with university participation. The CANTEACH program continues to accumulate information contributed by the Canadian nuclear industry, universities and the CNSC.

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

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. During the reporting period, an industry working group identified the need for a joint regulatory affairs training program and agreed to develop courses individually and then share them. Courses on the following topics were developed by individual licensees, the CNSC, and AECL and delivered on a pilot basis during the reporting period:

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

<u>Knowledge Retention Programs</u>

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

- mentoring and coaching staff (including new and existing junior or experienced staff) to transfer knowledge;

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

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

AECL has “small-scale centres of excellence” that are led by experienced AECL personnel and focus on retaining high-priority skills. These centres enable current technical leaders to document their knowledge and experience and to share it with selected potential technical leaders, through holding seminars and informal discussions and by developing Web sites. Currently, these centres focus on high-priority skills such as control and safety system concepts, electrical power systems, reactor structures, fuel handling, reactivity mechanisms, feeder and steam generator integrity and fuel channels.

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

Maintaining Research and Development Capability

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

With this in mind, COG produces a report on R&D capability in the Canadian nuclear industry every three years. This report examines and documents Canadian R&D capability in order to ensure adequate financial resources for R&D, with the view of supporting continued safe and reliable operation of NPPs. The 2006 report assessed the impact of the R&D funding stream during the previous three years (2003–2006) and of the resources anticipated for the subsequent three years (2006–2009). The need for R&D capability was identified, taking into account various licensee drivers including regulatory compliance, safe operation, NPP life cycle management, potential NPP life extension, emerging issues, and support for design modifications. The 2006 report indicated improvements in R&D capability from 2003 to 2006 and provided assurance that essential capabilities are being preserved to the extent practicable.

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.

12 a Role of the Regulatory Body Regarding Human Performance

Safe and reliable human performance is essential to assure the overall safety of licensed facilities and activities. When determining if NPP licence applicants are qualified and have made adequate provision for health, safety and the environment, the CNSC will evaluate how the applicant has considered human factors aspects of the activity to be licensed.

The CNSC regulatory policy entitled *Policy on Human Factors* (P-119) describes how the CNSC considers human factors during its licensing, compliance, and standards-development activities. According to this policy, human factors means "those factors that influence human performance as it relates to the safety of an NPP or activity over all phases, including design, construction, commissioning, operation, maintenance, and decommissioning." The CNSC assesses the adequacy of licensee programs developed to manage human performance, and monitors results from such programs. Human factors review areas include human factors in design, human reliability analysis, work organization and job design, procedures and job aids, human performance, performance monitoring, performance improvement, and organization and management.

The CNSC has issued the following regulatory guides to assist licensees and licence applicants in developing human factors engineering (HFE) activities:

- *Human Factors Engineering Program Plans* (G-276); and
- *Human Factors Verification and Validation Plans* (G-278).

12 b Licensees' Approach to Human Factors

<u>Responsibilities Related to Human Factors</u>

Each licensee incorporates an organizational and management philosophy that uses a hierarchical method to account for the capabilities and limitations of humans:

- 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; and
- Non-line organizations provide independent oversight of human performance.

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 for safety, as well as a questioning and self-checking attitude, are essential for minimizing human errors. (Safety culture is discussed further in Article 10.)

The primary method used to detect human error is direct observation and verification of employee performance. The flow of information and the communication of problems both up and down the line, including encouragement to admit human errors, are key to error detection.

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; and
- 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 Article 9) 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 (for example, laws, regulations and the licence) and internal boundaries (for example, OP&Ps, safety reports, *Radiation Protection Regulations* and quality assurance manuals);
- operating and maintenance practices; and
- design assumptions and intent.

Where possible, licensees ensure independent verification of actions or assessments prior to completion of work. This minimizes the occurrence of errors, and is a key step in mitigating the potential for human performance issues.

Methods to Prevent, Detect and Correct Human Errors

NPP licensees strive to maintain learning environments to identify and resolve all issues. 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.

In the Canadian nuclear industry, the principles of HFE are used to prevent, detect and correct human errors, at a level determined by specific circumstances. HFE is applied in new designs, from the conceptual design phase to final detailed design, installation and commissioning phases. In operating NPPs, HFE is also integrated in the development of procedures and into change control processes when any modifications are made. Operating experience is shared to minimize the risk of repeat incidents.

Design Activities

A rigorous HFE approach is used in the design of new reactors, especially for main control room and secondary control rooms or areas where panel displays are critical to decision making. A human factors engineering program plan (HFEPP) is prepared to ensure that design activities systematically consider human factors principles. Experience gained in earlier design work is used for new designs; for example, the lessons learned from CANDU 6/CANDU 9 designs were used in the development of the Advanced CANDU Reactor (ACR). Operating Experience (OPEX) reviews are also done while developing a new design to incorporate lessons learned by other members of the industry.

In any design associated with a modification or refurbishment to an existing facility, human factors considerations are incorporated in documented policies, procedures and instructions. This provides a systematic process with which to consider human capabilities and limitations in the design process. For making any modifications HFE is incorporated through constructability, operability, maintainability and safety review, independent verification and reviews by qualified personnel. Depending on the complexity of human interactions, an external expert in HFE may independently review the modification packages/procedures.

Examples of licensable activities for which an HFEPP would be appropriate are the design of a new facility, significant modification to a human-machine interface, or decommissioning activities. An HFEPP may be appropriate for other design activities if HFE involvement is warranted.

Operational Activities

Similar to its role in design activities, HFE is integrated in operating NPPs through policies and provides details in procedures and instructions. The rigour in maintenance and operating procedures and training minimize the risk of incidents due to human errors. Through multiple levels of verification of tasks and activities as well as pre- and post-job briefing and approvals by qualified personnel, human errors are typically prevented.

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.

A human performance improvement program established for the facilities encourages assessment of internal and external events and OPEX as opportunities to address problems before errors occur.

12 c CNSC Assessment of Human Factors Programs

“Human factors” is one of the three programs assessed by CNSC staff in the safety area “Performance Assurance” (see Table G.2 in Appendix G). During the reporting period, CNSC staff paid particular attention to implementation of human factors programs that fell short of the CNSC’s expectations. For example, based on a review of NPP performance information, submitted S-99 reports and CNSC inspection reports, CNSC staff identified numerous issues at Pickering A that indicated a downward trend in human performance. In 2004, inadequacies relating to the design process and hours of work were identified at Gentilly-2. In addition, Gentilly-2 demonstrated inadequacies related to the job and task analysis to support training for the position of control room operator. Finally, during an inspection in 2004, CNSC staff raised concerns about the justification and documentation of engineering and technically-based skills required for safe operations at Point Lepreau. This basis is required to support succession planning. NBPN made progress in addressing this issue in 2005 and 2006, but further work is required. In addition, CNSC staff identified deficiencies in NBPN’s process for monitoring compliance with limits on hours of work.

In the next reporting period, CNSC staff will continue to monitor closely the incorporation of HFE in the design and modification process, staffing levels and limits to hours of work. These factors may become even more important because of the increased activity in the industry and a shortage of qualified personnel in many disciplines. The increasing reliance on the use of contracted staff at the NPPs, and the necessary management and oversight thereof, will also be an area of focus.

Article 13 – Quality Assurance

Each Contracting Party shall take the appropriate steps to ensure that quality assurance program are established and implemented with a view to providing confidence that specified requirements for all activities important to nuclear safety are satisfied throughout the operating life of a nuclear installation.

13 a Implementation of Quality Assurance Programs

The regulations that accompany the promulgation of the NSCA require the implementation of quality assurance (QA) programs during the life cycle of the NPP:

- siting;
- construction;
- operation (maintenance, modification);
- decommissioning; and
- abandonment.

An application to construct an NPP must include a QA program for the design of the NPP. The licensee must also submit QA programs for activities in various phases of the life cycle of the NPP before these phases begin. All NPP licences specify the CSA-N286 series of standards as the regulatory requirement for power reactor QA programs.

In the third Canadian report, it was reported that a licence condition on QA was added to the operating licence for Gentilly-2. Hydro-Québec was to develop and implement a QA program that would meet the CSA-N286 series of standards by October 2004. A similar requirement was put in place for Point Lepreau. These requirements were satisfied in 2004.

The CSA-N286 series of standards is based on a set of QA principles. In order to achieve required quality, it is fundamental for an organization to establish a program that satisfies the following 16 principles:

1. The required quality and the means of achieving it will be defined;
2. A policy statement will be issued committing all units of the organization to the program (see Article 10 for information on safety policies of the licensees);
3. Organizational responsibilities will be defined and understood;
4. Personnel will be competent at the work they do;
5. Individuals will be held accountable for their work;
6. The right people will have the right information at the right time;
7. Relevant experience will be sought and used;
8. Work will be planned and controlled;
9. The right items, processes, and practices will be used;
10. Work will be verified to confirm that it is correct (those who verify work will do so independently from those who do the work);
11. Deficiencies will be identified and remedied;
12. The root cause of deficiencies will be determined and corrected;
13. Changes to accepted items, processes, and practices will be controlled;
14. The preparation and use of documents will be controlled;
15. Essential records will be maintained; and
16. Periodic assessments of program effectiveness will be conducted.

The CSA-N286 series includes the following standards:

- *Overall Quality Assurance Program Requirements for Nuclear Power Plants*;
- *Procurement Quality Assurance for Nuclear Power Plants*;
- *Design Quality Assurance for Nuclear Power Plants*;
- *Construction Quality Assurance for Nuclear Power Plants*;
- *Commissioning Quality Assurance for Nuclear Power Plants*;
- *Operations Quality Assurance for Nuclear Power Plants*; and
- *Quality Assurance of Analytical, Scientific and Design Computer Programs for Nuclear Power Plants*.

The requirements of the CSA-N286 series apply to safety-related systems, which are defined in Annex 13 a. The CNSC requires licensees to identify the safety-related items, activities and processes in accordance with the definition and reviews them for acceptance. The QA program is binding on all personnel whose work on the nuclear project can affect nuclear safety. This includes the work performed by organizations that are not part of the licensee's organization.

13 b Assessment of QA Programs

Licensee Assessments

The CSA-N286 series specifies general requirements for the conduct, independence, frequency, scope, and timing of the licensee’s audits of its QA programs. Audit results shall be documented and reported to and assessed by a level of management with sufficient responsibility to ensure that audit findings are addressed. For operating facilities, in addition to the required self-assessments and independent assessments, the plant management team shall conduct a formal annual review of the QA program’s effectiveness. As a minimum, the following shall be reviewed:

- analyses and trends of operating experience;
- analyses and trends of the results of independent assessments;
- analyses and trends of quantitative data such as amount of rework; and
- results of ongoing self-assessments.

When a licensee has to rely on other organizations to carry out work, the licensee must ensure that QA requirements are passed on to these organizations and are met. As the work progresses, the licensee will conduct real-time reviews, audits, and inspections to make sure that work meets requirements. Frequency is determined by factors such as safety significance and the performance of the organization.

CNSC Assessments

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

- work methods;
- management processes and results; and
- overall compliance.

Quality management is one of three programs assessed by the CNSC in the “Performance Assurance” safety area (see Appendix G). CNSC staff observed that Bruce Power is still moving from a traditional QA style of oversight to a more modern integrated management system approach. Although Bruce Power has put considerable effort into improving its quality management and oversight, the project is incomplete. Thus, the quality management programs of Bruce A and B were considered below requirements each year of the reporting period.

The quality management program at Darlington received a “C” grade in 2004 for implementation due to deficiencies in the categorization of problems and trending of causal factors. The program and its implementation met CNSC requirements in 2005 and 2006.

In the third Canadian report, it was stated that implementation measures of QA programs for pressure-boundary work for three licensees were of particular concern to CNSC staff. To mitigate this shortcoming until the licensees obtained appropriate certification for pressure-boundary work, CNSC staff was limiting some licensees’ authorization to perform pressure-boundary work and/or requiring them to subcontract fabrication work to certified companies.

During the reporting period, Bruce Power obtained approval for its upgraded QA program manual. Since November 2005, CNSC staff and Bruce Power staff have met quarterly to discuss progress in the implementation of the pressure-boundary program. The certificate of authorization audit by the Technical Standards and Safety Authority (TSSA), the provincial authority, was scheduled for May 2007.

In 2004, the TSSA assessed OPG’s application for certificates of authorization for pressure-boundary work (repairs, replacements, modifications and fabrications to its non-nuclear and nuclear pressure-retaining boundaries). It was found that OPG had successfully addressed new requirements for its QA programs. The TSSA subsequently awarded nine certificates of authorization to each site to cover the various scopes of work.

During the reporting period, CNSC staff reviewed the revised documentation in Hydro-Québec’s QA system related to pressure-boundary work. Hydro-Québec’s application for a certificate of authorization for pressure boundary work is currently being reviewed by the provincial authority (Régie du bâtiment du Québec [RBQ]). In the meantime, Hydro-Québec continues to use contractors to perform pressure-boundary work.

Point Lepreau continues to use contractors to perform pressure-boundary work.

13 c Overall Management System

<u>Existing Assessments by CNSC</u>

During the reporting period, the CNSC continued to assess the overall safety management of NPPs via inspections and integrated assessments of safety areas and programs, as described in Table G.2 in Appendix G. For example, the CNSC “Operating Performance” safety area includes programs that cover operations, organization and plant management, and occupational health and safety. During the reporting period, all licensees met the CNSC requirements for this safety area, as shown in Table G.3 in Appendix G.

The CNSC “Performance Assurance” safety area consists of three programs: training, human factors, and quality management. These programs are approximately aligned with Articles 11, 12, and 13, respectively. Table G.3 in Appendix G illustrates a general improvement in grades for “program” and “implementation” of the “Performance Assurance” safety area since 2003.

Development of Management System Requirements and Future Assessments

Licensees, AECL, and the CNSC participated in the development of a major revision of the CSA-N286 series of standards for NPP QA. The new CSA standard *Management System Requirements for Nuclear Power Plants* (N286-05) was published in 2005. The new standard describes a broader set of management system requirements than the old series (CSA-N286.0 to N286.6). A primary purpose of the new standard is to promote safe and reliable operation of NPPs, with a focus on management's role in controlling and managing work processes. As stated in CSA N286-05, safe and reliable NPPs require commitment and adherence to a set of management system principles and, consistent with these principles, the implementation of a planned and systematic pattern of actions that achieves the expected results. The principles, the required supporting actions, and the documentation that describes them constitute the management system.

While the old CSA-N286 series on QA is referenced in each licence, some licensees have already designed their management systems based on the requirements of the new standard, CSA-N286-05. However, these licensees have clearly shown that their programs and procedures are designed to meet the CSA-N286 series of QA requirements specified in their licences.

CNSC staff is planning to continue participating in the development of integrated management system requirements that are aligned with the IAEA safety standard *The Management System for Facilities and Activities* (GS-R-3).

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

Article 14 – Assessment and Verification of Safety

Each Contracting Party shall take the appropriate steps to ensure that:

(i) comprehensive and systematic safety assessments are carried out before the construction and commissioning of a nuclear installation and throughout its life. Such assessments shall be well documented, subsequently updated in the light of operating experience and significant new safety information, and reviewed under the authority of the regulatory body;

(ii) verification by analysis, surveillance, testing and inspection is carried out to ensure that the physical state and the operation of a nuclear installation continue to be in accordance with its design, applicable national safety requirements, and operational limits and conditions.

Comprehensive deterministic safety assessments are completed for Canadian NPPs before their first operation, and are documented in the plant safety reports. Safety analyses are updated periodically throughout the NPPs' lives, typically every three years (see subsection 14 (i) a). Probabilistic safety assessments (PSAs) are also periodically reviewed and updated as necessary (see subsection 14 (i) d).

Action #7 on Canada from the Third Review Meeting of the Convention involved evaluating the use of periodic safety reviews (PSRs). In this regard, it is noted that:

- Integrated safety reviews (ISRs), in accordance with the IAEA safety guide *Periodic Safety Review for Nuclear Power Plants* (NS-G-2.10), are being done in support of reactor re-start and life extension projects (subsection 14 (i) e);
- The licence renewal process used by the CNSC and the licensees is similar to the IAEA PSR process (subsection 14 (i) f); and
- Canada continues to evaluate the implications of introducing PSR into the regulatory framework for NPPs (see subsection 14 (i) f).

The following activities are undertaken to verify that the physical state and operation of an NPP meet applicable requirements for design, safety requirements, and operating limits:

- routine monitoring of plant conditions by operating staff in accordance with approved procedures, as well as routine testing, maintenance, inspection and audit programs (see Article 19 for details);
- special programs to monitor and manage potential degradation of major components (see subsection 14 (ii) a);
- independent external audits by organizations such as the World Association of Nuclear Operators (WANO) and the IAEA Operational Safety Assessment Review Teams (OSARTs) (see subsection 14 (ii) b); and
- regulatory monitoring by the CNSC, including compliance verification activities and reviews of licensee programs and performance as part of operating licence renewals (typically every five years) (see subsection 14 (ii) d).

Two of the safety areas (defined in Appendix G) for which CNSC staff rates the licensee programs and implementation are relevant to the assessment and verification of safety. The CNSC "Design and Analysis" safety area covers topics relevant to overall assessment, such as the preparation of the safety report, PSAs, and the handling of Generic Action Items (GAIs). The CNSC "Equipment Fitness for Service" safety area covers programs that are also relevant to this article, such as reliability programs (that use the results of the safety assessments) and the environmental qualification of equipment (relevant to verification of safety). In both of these safety areas, licensees generally met the CNSC's requirements and expectations for programs and their implementation during the reporting period (see Table G.3 in Appendix G). CNSC staff also judged that all NPPs had acceptable margins of safety during the reporting period.

14 (i) Comprehensive and Systematic Safety Assessments

14 (i) a Deterministic Safety Analysis

Under paragraphs 5(d), 5(e) and 5(f) of the *Class I Nuclear Facilities Regulation*, the safety report has to be completed and the methodology updated for both the construction licence and the operating licence. Under paragraphs 6(a) and 6(b) of the same regulation, an application for a licence to operate an NPP shall contain descriptions of the systems, structures and equipment of the facility, including their design and design operating conditions. Paragraph 6(c) further requires the application to contain a final safety analysis report demonstrating the adequacy of the design of the NPP. Details on the content of the safety report are provided in Annex 14 (i) a.

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

- a description of the changes made to the site, structures, systems and components of the NPP, including any changes to the design and design operating conditions of the structures, systems or components (SSCs); and
- safety analyses that have been appropriately reviewed and revised, and that take account the most up-to-date and relevant information and methods, including the experience gained and lessons learned from the situations, events, problems or other information reported pursuant to S-99.

Tools and methodologies used in the safety report have to be proven according to national and international experiences and validated against relevant test data and benchmark solutions. Licensees will update their safety analyses as necessary, based on lessons learned from national and international operating experience. A licence to construct a new NPP will not be granted by the Commission unless the preliminary safety report satisfies such requirements.

During the reporting period, the licensees' safety analyses, as described in the safety reports, demonstrated acceptable safety margins for all Canadian NPPs.

<u>Safety Analysis Methods and Acceptance Criteria</u>

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 off-site 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). The criteria are as follows:

- Radioactive releases due to normal operation, including process failures other than serious failures, shall be such that the dose to any individual member of the public affected by the effluents from all sources shall not exceed one-tenth of the allowable dose to nuclear energy workers;
- The effectiveness of the safety systems shall be such that for any serious process failure, the exposure of any individual of the population shall not exceed 5 mSv and of the population at risk, 100 person Sv; and

- For any postulated combination of a (single) process failure and failure of a safety system (dual failure), the predicted dose to any individual shall not exceed: 250 mSv to the whole body or 2.5 Sv to the thyroid.

These criteria continue to be used as part of the licensing basis for all Canadian NPPs except for the Darlington NPP. For the licensing of Darlington, the CNSC consultative regulatory document *Requirements for the Safety Analysis of CANDU Nuclear Power Plants* (C-006) was used on a trial basis. This document addressed deficiencies in the basic single/dual-failure safety analysis requirements and reflected Canadian experience in applying the single/dual-failure analysis approach.

The safety analysis requirements proposed in C-006 differed from previous practice in the following respects:

- a requirement was introduced for a systematic review to identify postulated initiating events;
- five event-classes replaced the two categories of single and dual failure;
- combinations of postulated initiating events with failures of mitigating systems (not just the classical dual failures) were explicitly required to be considered; and
- more sensitivity and error analyses were required.

In the reporting period, the CNSC decided to bring its safety analysis requirements in closer alignment with international standards, in particular with those promulgated through the IAEA. This has led to the development of a new draft regulatory standard, *Safety Analysis for Nuclear Power Plants* (S-310), which has undergone licensee and public review.

14 (i) b Generic Safety Issues

Generic safety issues are issues that may affect more than one station. Several generic safety issues have been grouped by CNSC staff under the label “Generic Action Items” (GAIs). GAIs are used as a regulatory tool to define the scope of key safety issues, identify outstanding technical issues, and specify requirements for resolution of the safety issue. GAIs are also used to monitor the progress of licensees with regards to safety issues, and provide a basis for communication of licensee progress.

The GAI program has helped maintain regulatory focus on complex safety-related issues. Several GAIs require the licensees to demonstrate the degree of certainty and conservatism in the safety analyses of design basis accidents. The GAI program has provided a vehicle for the CNSC to offer some degree of guidance on licensees’ safety research (see Appendix E). Many GAIs have contributed to an improved understanding of safety issues, while others have led to changes to procedures, equipment and analysis at NPPs in Canada. It should be noted that GAIs deal with situations where safety margins are believed to be adequate, but are subject to potential degradation. Hence, continued station operation is judged permissible. Issues with confirmed, immediate safety significance are addressed by other means on a priority basis (see subsections 7.2 (iii) and (iv) under Article 7).

As of 1 January 2004 up to the end of the reporting period, five GAIs were closed for all NPPs and a new one was opened concerning emergency core cooling (ECC) strainers. The following table provides an overview of the status of GAIs at the end of the reporting period (see Appendix F for a comprehensive description of all GAIs that were open during the reporting period).

Summary of GAI Status at End of Reporting Period

Status	OPG	Bruce Power	Hydro-Québec	NBPN
Work in progress to meet closure criteria	5	5	5	6
Closure requested	4	4	6	4
Total open GAIs	9	9	11	10

During the reporting period, the CNSC commenced work on a project to:

- survey generic safety issues related to CANDU reactors;
- rank these issues of importance; and
- develop a strategy to resolve these issues in the context of new NPPs as well as those in operation or being refurbished .

The ranking and strategy development will employ the CNSC's risk-informed decision making process (see subsection 8.1 d). Many of the issues have criteria that were developed for their closure.

14 (i) c Issues Identified by Safety Assessment

Demonstration of Adequate Safety Margins for Large LOCAs

Due to refinements in the modelling of void reactivity effects in computer codes used in safety analysis, as well as increasingly conservative treatments in safety analysis methodologies, analyzed large loss-of-coolant-accident (LOCA) safety margins have progressively eroded at all NPPs in Canada. The Chief Nuclear Officers of the Canadian NPP licensees have initiated, sponsored and overseen an industry-wide approach to resolve this issue. The Canadian Nuclear Utility Executive Forum (CNUEF) has discussed this approach (see Section C.3 in Chapter II), which will help in successfully addressing action #9 (see paragraph 9 of section C.2 in Chapter III) on Canada from the Third Review Meeting of the Convention.

The approach being taken includes a study of the feasibility of design changes to restore analysed safety margins, as well as the development and implementation of a Best-Estimate and Uncertainty (BEAU) methodology as an alternate licensing methodology. These would enable licensees to demonstrate that existing safety margins continue to be adequate. In addition, the industry is evaluating global progress in risk-informed methods, including break preclusion and risk-informed inspection, to assess how these methods can be applied to large LOCA in CANDU reactors. Application of risk-informed methods should provide increased assurance of event prevention, which is the first line of defence. Use of a risk-informed approach may also provide improved insights from an overall risk perspective, to ensure appropriate allocation of resources to this issue.

The newest version of the CANDU reactor, the ACR-1000, is being designed with a negative coolant void reactivity coefficient, which effectively eliminates the large LOCA margins issue. Canadian licensees that are considering building new reactors are evaluating the ACR-1000.

The progress on industry initiatives to address large LOCA safety margins is reviewed in the following paragraphs.

Core Conversion at Bruce B

Bruce Power has proceeded with the option of changing from fuelling against the flow (FAF) to fuelling with the flow (FWF) to improve overpower transient response to large LOCAs. 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 large LOCA. This is a significant engineering and operational change that improves large LOCA safety margins.

The cores of Bruce A Units 3 and 4 were converted to FWF before their return-to-service in late 2003 and early 2004, respectively. During the reporting period, the conversion from FAF to FWF was completed in Units 6 and 7 at Bruce B. This increased the safety margins for large LOCA. The CNSC amended the Bruce B operating licence to allow those reactors to increase to 93% full power. Units 5 and 8 remain limited to 90% full power due to the same power pulse issues, but Bruce Power is currently converting Unit 5 to FWF and will then convert Unit 8.

Low-Void-Reactivity Fuel

To restore the safety margin for a large LOCA, Bruce Power is evaluating a low-void-reactivity (LVR) fuel, for which the conceptual design is well established. A safety case for a demonstration irradiation was made, and a safety case for a full core loading is being developed. CNSC staff would review both safety cases prior to implementation.

The Commission amended the Bruce B operating licence to permit a demonstration irradiation of LVR fuel bundles, commencing in 2006 in Unit 7. Two fuel channels were selected and will operate with LVR fuel until the next scheduled Unit 7 maintenance outage in 2008. At that time, the LVR fuel bundles will be removed from the reactor and inspected. The fuel channels will also be inspected to confirm that no damage has occurred from the new bundle design. This is the final stage before full core implementation, which will likely occur in Bruce A Units 1 and 2.

Plant Refurbishments

NPPs undergoing refurbishment in Canada (Point Lepreau and Units 1 and 2 at Bruce A) are implementing changes that will have a small, but beneficial effect on large LOCA margins. These changes will include replacing aged pressure tubes with new ones, which will slightly reduce the full core void reactivity (the aged tubes have crept diametrally, thereby increasing void reactivity). The new tubes will be built to the original specification. While these will also inevitably age, other measures are expected to be in place by the time that becomes an issue.

Best-Estimate Analysis and-Uncertainty

Canadian licensees have been developing a new method of analysis, the Best-Estimate Analysis and Uncertainty (BEAU) methodology, to augment their deterministic safety analysis. The objective of developing the BEAU methodology is to demonstrate the existence of larger safety margins, as compared to the margins produced by the conservative deterministic safety analysis methodology for design basis events like large LOCAs and loss-of-flow accidents. This analysis 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. The BEAU methodology is currently not considered to be a licensing tool. However, after remaining uncertainty and validation issues are resolved and as it matures and gains increased confidence by both the CNSC and licensees, the BEAU methodology may be used as a licensing safety analysis tool. A pilot BEAU project Darlington was completed in March 2003 and demonstrated significantly improved margins as compared to traditional "Limit of Envelope" analysis results. Large LOCA BEAU analysis for Pickering B units was subsequently initiated in 2004 and is nearing completion.

Improvements in Safety Analysis Methods

Current R&D, as well as code development and validation for advanced reactor design in Canada are expected to apply to methods and safety analysis for operating NPPs. The information is expected to address issues related to code validation and application of research-reactors result as they apply to large LOCA analysis.

Erosion of Safety Margins from Heat Transport System Ageing Effects

Some important ageing mechanisms in the heat transport system (HTS) of a CANDU reactor (for example, pressure tube diametral creep, steam generator fouling and increases in feeder roughness) can affect the neutron overpower analysis and the adequacy of reactor trip setpoints in the event of a loss of regulation. Reactor power at Point Lepreau has been limited (for example, to 91% of full power near the end of the reporting period) to account for these effects. In 2007, Gentilly-2 was limited to between 95% and 97% full power to compensate for similar concerns related to HTS fouling and pressure tube diametral creep. The industry has undertaken measures to better understand and mitigate these effects and improve relevant analyses. For example, Hydro-Québec has conducted mechanical cleaning of steam generator tubes and precise measurements of the internal diameters of installed pressure tubes. Recognizing the possibility of de-ratings at their NPPs, OPG and Bruce Power submitted assessments using an enhanced methodology that incorporates a different treatment of uncertainties and different assumptions with respect to the initial core configuration. Discussions are in progress with the CNSC regarding the acceptability of the enhanced methods.

14 (i) d Use of Probabilistic Safety Assessments

The licensees developed PSAs and periodically review and update them as necessary, in conjunction with deterministic safety analysis.

The CNSC issued the regulatory standard *Probabilistic Safety Assessment for Nuclear Power Plants* (S-294) in April 2005. It has been incorporated into the operating licences for Point Lepreau and Gentilly-2 and is also planned for incorporation into other operating licences upon their renewal. This standard refers to the following IAEA documents as providing general guidance for conducting quality PSAs:

- *Procedures for Conducting Probabilistic Safety Assessments of Nuclear Power Plants (Level 1)* (Safety Series No. 50-P-4); and
- *Procedures for Conducting Probabilistic Safety Assessments of Nuclear Power Plants (Level 2), Accident Progression, Containment Analysis and Estimation of Accident Source Terms* (Safety Series No. 50-P-8).

Annex 14 (i) d reviews the status of the PSAs at each Canadian NPP. PSAs and their updates are reviewed by CNSC staff. Licensees are at various stages of developing and updating their PSAs and using the results. Typical applications of the PSA results include their use in conjunction with deterministic analytical results to refine programs for reliability and maintenance. For example, PSA results are used to help identify the “systems important to safety” for the reliability program (see section 19 (iii)).

14 (i) e Application of PSR and Safety Improvements to Life Extension Projects

As noted in the introduction to Article 14, ISRs are being performed in support of reactor re-start and life extension projects. NPP licences are amended to introduce specific licence conditions for the regulatory control of life extension projects. Approval for a reactor’s return-to-service is contingent upon the licensee’s demonstration that all relevant licence conditions have been met.

An ISR is a comprehensive assessment of plant design, condition and operation. It is performed in accordance with the IAEA PSR safety guide NS-G-2.10. It is referred to as an ISR due to its one-time application of a PSR to a life extension project. Performed by the licensee, the ISR is an effective way to obtain an overall view of plant safety. It 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 permit long term operation.

The ISR's objectives are to determine:

- the extent to which the plant conforms to modern high-level safety goals and requirements;
- the extent to which the licensing basis remains valid;
- the adequacy of the arrangements in place to maintain plant safety for long-term operation; and
- improvements to be implemented to resolve the identified safety issues.

The scope of an ISR involves an assessment of the plant's current state and performance, in order to determine the extent to which it conforms to modern high-level safety goals and requirements. Operating experience in Canada and around the world, new knowledge from research and development activities, and advances in technology are all taken into account.

The safety factors to be addressed in an ISR are listed in the IAEA PSR safety guide NS-G-2.10. In addition, the scope of an ISR should address the CNSC's safety areas and programs used for licensing and other assessments (see subsection 14 (ii) c). Table 3.14.1 of the third Canadian report provides a description of the alignment between the PSR safety factors and CNSC safety areas and programs. An ISR should also address all GAIs and station-specific action items, with each being resolved to the extent practicable.

The following paragraphs provide details of restart and life extension projects during the reporting period, and their respective ISR results.

<u>Point Lepreau Refurbishment</u>

Refurbishment of Point Lepreau will involve replacement of fuel channels, feeders and calandria tubes and modification or replacement of other safety-significant components and systems.

The ISR for Point Lepreau did not find any significant safety issue or condition not already being addressed (deficiencies that were observed can be addressed by the station's corrective action program).

The ISR concluded that the safety factors comprising a PSR are being addressed at Point Lepreau and that the objective of a PSR has been met. That means that:

- The plant is safe to operate, as judged by current safety standards and practices; and
- The regulatory process and industry's approach to maintaining safe operation provide assurance that significant safety issues will be addressed if they arise upon the station's continued operation or life extension.

<u>Bruce A Refurbishment</u>

Refurbishment for life extension and continued operation would require:

- replacing major reactor components such as the steam generators, feeder pipes, calandria tubes and fuel channels to restart Units 1 and 2;
- replacing the fuel channels and steam generators on Unit 3; and
- installing new steam generators on Unit 4.

Unit 2 is the lead unit for return-to-service, with a planned return in early 2009. Unit 1 is scheduled to return to service six months after Unit 2.

Bruce Power has not yet committed to the refurbishment of Units 3 and 4. However if this were to proceed, the Unit 3 refurbishment would likely occur shortly after the return-to-service of Unit 1, followed by steam-generator replacement in Unit 4 in the year 2010.

Following the refurbishment outages, the reactor units will be refuelled and returned to full-power operation. It is anticipated that LVR fuel will be loaded into the refurbished reactors after the core reaches equilibrium after restart.

Bruce Power is conducting its refurbishment studies using the draft CNSC regulatory guide *Life Extension of Nuclear Power Plants* (G-360) on a trial basis (see subsection 7.2 (i) for details on G-360).

Bruce Power has prepared an ISR for the refurbishment of Bruce A Units 1 and 2. CNSC staff is currently reviewing it.

Pickering A Restart

In 2005, Pickering A Unit 1 was returned to service to join Unit 4, which had been returned to service in 2003. These two units were restarted following extensive upgrades, including major enhancements to shutdown system capability, improved equipment for fire detection, suppression and prevention, seismic upgrades, new environmentally qualified cabling, emergency service water, and improvements to the emergency core cooling systems.

Pickering B Refurbishment

Refurbishment of Pickering B would involve replacing major reactor components such as the steam generators, feeder pipes, calandria tubes and fuel channels.

OPG is currently assessing the feasibility of refurbishing Pickering B for life extension and continued operation until 2050–60. This systematic, thorough review by OPG will culminate in a refurbishment decision that will likely be made in 2008. The feasibility study is being carried out using the draft CNSC regulatory guide G-360 on a trial basis (see subsection 7.2 (i) for details on G-360).

Planning assumes that each unit would be refurbished in sequence, based on a refurbishment outage of 2 to 2.5 years per unit. The total duration of refurbishment outages would be 8 to 12 years, depending on the scope of the work.

14 (i) f Consideration of PSR for Operating Reactors

The third Canadian report noted that, as part of the operating licence renewal process for NPPs (see subsection 7.2 (ii) e), the CNSC and the licensees already practice a form of periodic safety review similar to that of the IAEA. Annex 3.14.1 of the third Canadian report showed how the IAEA PSR safety factors (from NS-G-2.10) were aligned with generic Canadian licensing requirements, as well as restart and refurbishment activities in progress at the time. During 2004–05, in response to action #7 from the Third Review Meeting of the Convention, CNSC staff evaluated the implications of formally adapting the IAEA PSR in the regulatory process. CNSC staff noted that certain aspects of the IAEA PSR methodology should be considered in the enhancement of the regulatory oversight of NPPs. Additionally, in the context of adopting the PSR methodology, a consultant report was prepared for the CNSC, and the CNSC participated in two international meetings (general PSR and CANDU-specific PSR).

The consultant report included a review of implementation of PSR in other countries. It also included a review of best practices, lessons learned and information on the regulatory decision-making process used in other countries.

Possible advantages of incorporating the PSR into the regulatory process include the following:

- identifying potential improvements to maintain a high level of safety and to improve the safety of older plants to a level comparable to that of modern plants;
- identifying back-fitting priorities;
- enhancing clarity and transparency of the regulatory process in terms of requirements and acceptance criteria; and
- aligning CNSC practices more transparently with international practices.

Currently, the Canadian Nuclear Utility Executive Forum is discussing various aspects of adapting PSR methodology into the Canadian licensing regime. A decision related to the use of PSR must consider factors such as the frequency of public access to the licensing process, the effectiveness and efficiency of the proposed changes, and the additional burden that may be imposed on the regulator and the licensees. Current licensing and compliance frameworks may need to be revised to fully align with the PSR process.

If the CNSC makes the decision to use PSR, it is anticipated that it will be introduced and implemented in Canada over a period of several years.

14 (ii) Verification

14 (ii) a Ageing Management Plans

Operating, inspection and maintenance experience with several significant material degradation mechanisms during the life of currently operating nuclear power plants in Canada has led to the development, formalization and documentation for a number of focused materials degradation management plans. These plans provide for materials and component inspection and assessment techniques and intervals to ensure that all safety-significant systems, structures and components are maintained within the safe operating limits allowed by relevant codes and standards. These plans are regularly reviewed and updated as required to incorporate and allow for new information and findings. CNSC staff regularly reviews the results of activities covered by the ageing management plans.

The ageing management plans maintained by the licensees during the reporting period included the plans mentioned in following paragraphs.

Heat Transport System Materials Degradation Management Plan

This is an overview document summarizing the responsibilities, design requirements, operating experience, degradation mechanisms and acceptance standards for structures and components of the primary Heat Transport System (HTS). The document describes the strategy to manage HTS materials and identifies specific component sub-programs and the key interfaces between various station programs and processes.

Feeder Pipe Management Plan

This program controls risks related to feeder ageing and degradation mechanisms. It contains a review of contributing factors and predicted degradation and failure rates from which maintenance strategies are derived. Specific program inspection and corrective maintenance activities are described, including wall thickness inspections and programs to manage flow accelerated corrosion, preferential weld attack, fretting and cracking mechanisms.

Fuel Channel Life Management and Inspection Plan

This plan reviews fuel channel degradation mechanisms with the potential to affect the life of fuel channels. The document also presents the strategies established to ensure the effects of component ageing are monitored and managed effectively. It also discusses potential degradation mechanisms such as dimensional changes due to service conditions (axial and diametral expansion, wall thinning and tube sag), deuterium uptake, fracture toughness changes due to service conditions and induced changes to material properties, pressure tube to calandria tube contact due to dimensional changes and garter spring displacement and the potential for blister growth and re-fuelling related service-induced damage to inside surfaces.

Flow Accelerated Corrosion

This program identifies susceptible systems and monitors and manages degradation related to flow-accelerated corrosion in secondary side (non-nuclear) pipe-work systems. This program is based on the Electric Power Research Institute program CHECWORKS for assessment of predicted wear rates and remaining service life. A sub-program model is used for pipe-work that cannot be modelled using CHECWORKS due to out-of-scope operating conditions or geometries (such as lines with entrained moisture, non condensable gases and mitred fittings).

Steam Generator Management Plan

This program controls risks related to steam generator ageing 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 deposit management and removal (via water lancing, blow-down practices during operation and occasional chemical cleaning).

14 (ii) b Completion of Environmental Qualification Projects

As described in the third Canadian report, all licensees have had projects under way since the 1990s to provide re-assurance of the environmental qualification of safety and safety-related systems for all design basis accident conditions. A licence condition was imposed on all plants to complete these projects by June 30, 2004.

These projects are now complete at all NPPs, with the exception of a few modifications that require unit outages to complete. The results foster greater confidence that the systems will operate as intended during all design basis accidents

A new CSA standard, *Environmental Qualification of Equipment for CANDU Nuclear Power Plants* (N290.13-05), was published in 2005. Operating licences are being amended to require compliance with it as they come up for renewal.

14 (ii) c Independent External Monitoring of Safety Performance

World Association of Nuclear Operators Reviews

All Canadian utilities are members of the World Association of Nuclear Operators (WANO). Each utility invites the WANO to perform peer reviews at the nuclear plants approximately every 2 years to review performance, compare against international standards, and identify areas for improvement. Recent WANO peer reviews in Canada include:

- Bruce May 2005
- Pickering B June 2006
- Pickering A December 2006
- Gentilly-2 2005
- Point Lepreau October 2004

Planned WANO peer reviews in Canada include:

- Bruce May 2007
- Darlington June 2007
- Gentilly-2 February 2008
- Point Lepreau October 2007

In a peer review, an NPP licensee invites a WANO team of about 20 people to spend two weeks at a plant observing personnel performing their jobs, conducting interviews and reviewing documentation. All areas are reviewed in accordance with specific WANO performance objectives and criteria.

Pickering A Operational Safety Review Team Mission

A review by an Operational Safety Review Team (OSART) was conducted by the IAEA at Pickering A in February 2004. Following standard practice, the IAEA was invited to return to Pickering A in September 2005 to assess OPG's progress in addressing the OSART's recommendations and suggestions. The purpose of the follow-up visit was to determine the status of all proposals for improvement, to comment on the appropriateness of the actions taken, and to assess the degree of progress achieved.

The OSART follow-up review team categorized the status of all corrective actions and provided comments on them, including some additional suggestions for improvement. It found that, of the 23 issues, including 12 recommendations and 11 suggestions identified by the OSART mission in February 2004, 10 were considered resolved and 13 were found to have made satisfactory progress toward completion. The team identified adherence to steam door and fire door requirements as a remaining area for improvement, but also noted visible improvement in plant housekeeping and foreign material exclusion practices.

The overall conclusion of the review was that the plant made significant progress in correcting all issues identified during the 2004 OSART mission. Strategic plans were developed, responsibilities were assigned, corrective actions were being addressed, modifications were planned, and results were trended and communicated. The team also noted good management and staff engagement in the many long-term initiatives to ensure the sustainability of results.

14 (ii) d Verification of Safety by CNSC Staff

The CNSC typically grants NPP operating licences for periods of five years (see subsection 7.2 (ii) e). However, safety analysis reports and safety system reliability studies are reviewed on a regular basis, typically at a frequency greater than that of operating licence renewal. In addition, processes for the routine monitoring of licensee performance encompass a comprehensive scope of activities by the regulator. These activities include mid-term assessments, inspections, and annual comparative safety assessments. In addition, routine evaluations, daily operational reviews, and assessment of safety-significant events, human factors and modifications are performed. Licensees also submit, under S-99 (see subsection 7.2 (iii) c), reports of events to the CNSC, as well as quarterly and annual reports on matters such as operations, performance indicators, periodic inspections, status of pressure boundaries, radiation protection and reliability. The most safety-significant situations are pursued by special reviews or focused inspections that are often followed up through specific action items for events at individual sites, or under GAIs (see subsection 14 (i) b).

The CNSC has standardized nine safety areas, each encompassing one or more programs used by licensees and the CNSC to assess the safety of NPPs in Canada. These nine safety areas were determined based on their relationship with the risk associated with plant operation. Appendix G includes Table G.2 on the CNSC safety areas and programs and Table G.1 that describes the CNSC rating system used to assess them.

The licences issued by the CNSC contain requirements for the review and approval of changes to the safety and safety-related structures, systems and components (SSCs), operating documentation and limits and other specified documentation. These conditions permit the CNSC to verify that proposed modifications to SSCs, operating procedures or other limits will not significantly affect the existing margin of safety for the plant that was agreed upon at the time of licensing.

Article 15 – Radiation Protection

Each Contracting Party shall take the appropriate steps to ensure that in all operational states the radiation exposure to the workers and the public caused by a nuclear installation shall be kept as low as reasonably achievable and that no individual shall be exposed to radiation doses which exceed prescribed national dose limits.

15 a General Provisions Associated With the Control of Radiation Exposure of Workers and the Environment

A summary of regulatory requirements and guidance associated with the control of radiation exposure of workers and the environment is provided in Annex 15 a.

Canadian NPP licensees establish, maintain and document programs to effectively manage and control radiological risk to workers, the public and the environment from nuclear operations. These programs have the following objectives:

- to maintain a low level of public risk compared to other normal public risks that arise from industrial activity; and
- to subject workers only to radiological risks that are low, understood, and voluntarily accepted.

To verify compliance with licence conditions and CNSC regulations, CNSC staff reviews documentation and operational reports submitted by licensees and evaluates the licensees' radiation protection and environmental protection programs.

CNSC staff also:

- monitor and evaluate the radiological and environmental impacts of licensed activities;
- review documentation and applications submitted by licensees and dosimetry service proponents; and
- conduct on-site evaluations of dosimetry service applicants.

An important method for assessing licensee performance relates to unusual events. The CNSC regulatory standard *Reporting Requirements for Operating Nuclear Power Plants* (S-99) requires licensees to report certain events to the CNSC and to further analyze these events to identify causes and determine trends. For events related to potential and actual exposure to radiation, CNSC staff reviews the reporting and analysis processes of licensees to verify their compliance with regulatory requirements and effectiveness in correcting weaknesses. CNSC staff also investigates significant events.

15 b Application of the ALARA Principle

ALARA stands for 'as low as reasonably achievable, social and economic factors being taken into account'. To minimize doses to workers, licensees implement comprehensive ALARA strategies that are consistent with the IAEA's Safety Guide *Radiation Protection and Radioactive Waste Management in the Operation of Nuclear Power Plants* (NS-G-2.7). The following practices assure that radiation doses are ALARA:

- management control over work practices;
- personnel qualification and training;
- control of occupational and public exposure to radiation; and
- planning for unusual situations.

The following text presents three particular licensee strategies to minimize the dose to workers.

Radiological Exposure Permits

The NPPs' ALARA sections prepare and approve radiological exposure permits for all planned radioactive work. Permits are also prepared as required for emergent work. Radiation exposure permits help to control doses by allowing them to be tracked by job, which aids in presenting radiation protection issues during pre-job briefings. This reduces the probability of unplanned exposures that exceed the internal investigation level and facilitates post-work ALARA reviews of high-hazard or high-dose jobs.

Airborne Tritium Reduction

Several initiatives have been undertaken to reduce doses from tritium, including more frequent replacement of desiccant in dryer units and improvement of the material condition of dryer systems. Some licensees have also placed dehumidifiers on the air inlets of reactor buildings; installed alarming area tritium monitors, de-tritiated their heavy water inventory, and emphasized training on the potential hazards of tritium. The majority of doses due to airborne tritium arise from the heat transport system due to its higher temperature and pressure relative to those of the moderator system.

Source Term Reduction Program

Wherever consistent with the principle of ALARA, hot spots, which can increase radiation fields and contribute to radiation doses, are identified and removed. In addition to the removal of existing hot spots, licensees are working to reduce the recurrence of hot spots through initiatives that involve reduction of the filter pore size or increase in the flow rate in the heat transport purification system.

Each year, licensees establish aggressive radiation dose targets, which are essentially constraints as recommended in the IAEA Safety Guide *Radiation Protection and Radioactive Waste Management in the Operation of Nuclear Power Plants* (NS-G-2.7). These targets are based on planned activities and outages for the year; therefore, both targets and doses vary annually.

15 c Dose Limits and CNSC Assessment of Radiation Protection Programs for Workers

Doses to plant personnel were below regulatory limits during the reporting period (see Annex 15 c for doses to personnel at Canadian NPPs). While average and maximum doses remained relatively constant, the collective dose increased, largely due to reactor restarts, extended outages and feeder tube inspections. Dose control was particularly challenging for feeder tube inspections as these required hundreds of feeder tubes to be individually inspected. Nevertheless, all worker annual doses were well below the annual limit.

During the reporting period, the licensee programs for radiation protection of workers met CNSC requirements every year, in most cases (see Appendix G, Table G.3). Deficiencies in the implementation of the radiation protection program at Gentilly-2 were corrected. This resulted in the grade for the "Radiation Protection" safety area at Gentilly-2 changing from "below requirements" to "meets requirements" (see Appendix G, Table G.1 for definitions).

15 d Environmental Radiological Surveillance

Routine reactor operation and maintenance result in small releases of radioactivity. The CNSC restricts the amount of radioactive material that may be released in effluents. These effluent limits are derived from the public dose limit of 1 mSv and are called derived release limits (DRL). A DRL is an effluent release limit for a particular route of release from a particular station. If the station exceeds its DRL, members of the public with the greatest exposure may exceed the public dose limit.

Licensees set action levels well below the DRLs. An action level, if exceeded, provides a warning of a possible loss of control in the control systems and allow for prompt corrective action. This enables licensees to keep liquid and gaseous effluent releases well below their respective DRLs.

Canadian NPPs have established programs to control and monitor the effect of operations on human health and the environment. Licensees monitor airborne emissions for tritium, iodine, noble gases, carbon-14 and particulates, as well as waterborne emissions for tritium, carbon-14 and gross beta-gamma radioactivity.

In addition to tracking radiological emissions from the NPP, licensees have instituted radiological environmental monitoring programs to monitor radioactivity near the facilities in the air and in substances that people eat, drink and contact. These environmental monitoring programs have the following four objectives:

- to confirm that emissions of radioactive materials are within the DRL for specific nuclides or nuclide groups;
- to verify that the assumptions made in deriving DRL remain valid;
- to permit an independent estimate to be made of doses to critical members of the public resulting from emissions; and
- to provide data to aid in the development and evaluation of models that adequately describe the movement of radionuclides through the environment.

Health Canada, a federal agency, and the Province of Ontario also carry out monitoring programs around all NPPs (see the first and second Canadian reports for more details).

Health Canada established the Canadian Radioactivity Monitoring Network for environmental radioactivity in 1959. This Canada-wide network aimed initially at monitoring fallout from atmospheric nuclear weapons testing. The current program offers Canadians more accurate health assessments based on existing levels of radioactivity as well as radioactivity that may result from a nuclear accident. The program consists of monitoring ambient gamma radiation at 34 sites, radioactive aerosols at 26 sites, and atmospheric tritium at 15 sites. These tests are augmented in a few locations with drinking water and milk sampling. The Ontario Ministry of Labour's Radiation Protection Service also monitors environmental radiation within the province of Ontario.

Releases of gaseous and liquid effluents from Canadian NPPs from 2003 to 2005 are tabulated in Annex 15 d. During the reporting period, releases from all NPPs were kept at approximately 1% of the DRLs. In 2006, there were no reported cases of environmental action levels being exceeded.

15 e CNSC Assessment of Licensee Programs for Environmental Protection

CNSC staff evaluates the licensees’ environmental protection programs to protect the public and environment from releases of radioactive and hazardous substances. Programs under the “Environmental Protection” safety area and their implementation met CNSC requirements at all Canadian NPPs during the reporting period (see Appendix G, Table G.3).

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 Provision and Testing of Emergency Plans

16.1 a General Responsibilities of the Licensees, Regulatory Body and other Authorities

Nuclear emergency preparedness and response in Canada is a multi-jurisdictional responsibility shared by the federal, provincial and municipal governments as well as licensees. Nuclear emergency planning includes plans for both on-site and off-site emergencies.

On-site nuclear emergencies are those that occur within the physical boundaries of a Canadian NPP, and for which licensees are responsible. Off-site nuclear emergencies are those emergencies having an effect outside the boundaries of a Canadian NPP, and for which Provinces have the primary responsibility. The Provinces also designate municipalities within their jurisdictions to plan for off-site nuclear emergencies.

The provincial governments are responsible for the following activities:

- overseeing the general health, safety and welfare of the inhabitants of their respective provinces and the protection of the environment;
- enacting legislation to fulfill the province's lead responsibility for public safety;
- preparing emergency plans and procedures and providing direction to municipalities so designated;
- assuming lead responsibility for the arrangements necessary to respond to the off-site effects of a nuclear emergency; and
- co-ordinating support from the NPP and the Government of Canada during preparedness activities and during response.

The Government of Canada coordinates federal actions in support of the provinces during a nuclear emergency. Potentially, this collective responsibility encompasses a wide range of contingency and response measures to prevent, correct, or eliminate accidents, spills, abnormal situations and emergencies.

The Government of Canada has procedures to respond to emergencies with international or inter-provincial implications and is responsible for the following activities:

- liaison with the international community;
- liaison with diplomatic missions in Canada;

- assisting Canadians abroad; and
- coordinating the national response to a nuclear emergency occurring in a foreign country.

A federal department, Public Safety Canada, formerly known as Public Safety and Emergency Preparedness Canada, was created in December 2003 to integrate into a single portfolio the core activities that secure the safety of Canadians in emergencies, including radiological and non-radiological emergencies. Canada's "critical infrastructure" was defined as those physical and information technology facilities, networks and assets which, if disrupted or destroyed, would have a serious impact on the health, safety, security or economic well-being of Canadians. NPPs and nuclear technologies were identified as part of this critical infrastructure.

16.1 b On-Site Emergency Plans

Besides being required by various jurisdictions, on-site nuclear emergency plans are required by a licence condition for operating NPPs. Paragraph 6(k) of the *Class I Nuclear Facilities Regulations* specifies the information related to emergency preparedness that must accompany an application for a licence. Specifically, the application must describe the proposed measures to address the following situations:

- assist off-site authorities in planning and preparing to limit the effects of an accidental release;
- notify off-site authorities of an accidental release or the imminence of an accidental release;
- report information to off-site authorities during and after an accidental release;
- assist off-site authorities in dealing with the effects of an accidental release; and
- test the implementation of the measures to prevent or mitigate the effects of an accidental release.

After the plans have been reviewed and accepted by the CNSC, they become binding upon the licensee, as a condition in the operating licence. Descriptions of the on-site emergency plans for each NPP are provided in Annex 16.1 b.

CNSC staff evaluates the emergency preparedness for each licensee on an ongoing basis. The program component of the "Emergency Preparedness" safety area was judged by CNSC staff to exceed requirements at all NPPs in 2006 (see Appendix G, Table G.3). The implementation of those programs at the NPPs was judged to either meet or exceed requirements in 2006.

16.1 c Off-Site (Provincial and Territorial) Emergency Plans

The Canadian provinces and territories, in cooperation with local jurisdictions, have established plans to deal with any significant off-site nuclear impacts. Typically, their administrative structure includes an emergency measures organization, or equivalent, to cope with a wide range of potential or actual emergencies in accordance with defined plans and procedures.

The provincial and territorial emergency preparedness plans provide for coordination with other relevant jurisdictions and organizations. They anticipate the involvement and support of the Government of Canada at the national level, the involvement and support of both municipal and civic governments at the local level, and extensive participation by departments and agents of all levels of government. More details on this coordination are provided in subsection 16.1 d.

Typically, the provincial plans provide for urgent protective actions if required and include the following measures:

- limiting access to the affected zone;
- providing temporary shelter to the affected population;
- blocking thyroid uptake of radiation; and
- evacuating areas near the NPP.

The plans also recognize that ingestion control measures (for example, effecting a quarantine of farm animals, banning the sale of affected food, or restricting the use of affected drinking water) for a larger area could be necessary.

The off-site nuclear emergency plans of the provinces that host NPPs are described in Annex 16.1 c.

16.1 d Federal Emergency Plans

Federal Nuclear Emergency Plan

To the extent possible, the Government of Canada's emergency planning, preparedness and response are based on an “all-hazards” approach. Because of the inherent technical nature and complexity of a nuclear emergency, hazard-specific planning, preparedness and response arrangements are required. These special arrangements, which are one component of the larger federal emergency preparedness framework, constitute the Federal Nuclear Emergency Plan (FNEP). This plan describes the Government of Canada's preparedness and coordinates response to a nuclear emergency. Health Canada is the lead federal department for the FNEP.

The FNEP is intended to complement the relevant nuclear emergency plans of other jurisdictions inside and outside Canada. It describes the measures the Government of Canada will follow to manage and coordinate federal response activities to nuclear emergencies that could affect Canada. The FNEP is activated if federal support to a Canadian province or territory is required as a consequence of any domestic, trans-boundary (for example, Canada and the United States) or international incident.

Under the common administrative framework of the plan, the development and implementation of emergency preparedness and response plans to off-site nuclear emergencies, is primarily a provincial responsibility. However, there are direct inputs from the local government, the NPP, and federal departments and agencies. This allows the various jurisdictions and organizations that have responsibilities for aspects of nuclear emergency preparedness to discharge their responsibilities in a cooperative, complementary and coordinated manner.

There are 19 federal departments/agencies involved in the FNEP. In keeping with the FNEP, federal policies, and Canadian legislation, these participants are also responsible for independently developing, maintaining and implementing their own nuclear emergency response plans. The CNSC has clearly defined roles within the context of the FNEP: for example, it is a core member of each of the FNEP's four organizational groups (coordination, operations, technical advisory and public affairs), and participates in emergency planning activities with other FNEP core agencies.

Annex 16.1 d describes the provisions of the FNEP.

Emergency Plans of Federal Departments and Agencies

The CNSC has its own nuclear emergency response plan. A general description of the CNSC’s role in emergency preparedness is provided in Annex 16.1 d. The CNSC is in the process of improving its nuclear emergency management program within the framework of the recently issued regulatory policy *Nuclear Emergency Management* (P-325). The improved program will include a revised CNSC emergency response plan and operational instructions for CNSC staff. The CNSC intends to complete the training and implementation of the new program by the end of 2007.

As reported in the third Canadian report, the CNSC emergency operations centre operates using public electricity and, during the loss of the electricity grid (blackout) of August 14, 2003, experienced difficulties with the power supply. The offices of another federal agency that were equipped with backup power were available if needed and the CNSC was able to get essential information about the affected

NPPs. During the reporting period, the CNSC installed an emergency generator at its headquarters to enable continued regulatory activities and communication during a loss of public electricity.

Other federal departments and agencies also develop their own nuclear emergency response plans. For example, Transport Canada administers the Canadian *Transportation of Dangerous Goods Regulations* and operates the Canadian Transport Emergency Centre to make sure that hazardous substances are transported safely and to help emergency response personnel handle related emergencies, including those involving nuclear substances. The CNSC and Transport Canada cooperate in emergencies and incidents involving nuclear substances in accordance with the FNEP, relevant federal legislation, and formal administrative arrangements.

16.1 e Exercises and Drills

Emergency drills are designed to provide a training opportunity to enhance the ability of involved parties to respond to emergency situations and protect public health and safety during an event at an NPP or other licensed nuclear facility. Emergency exercises serve to test the sharing of information and to ensure all response efforts are coordinated and communicated effectively.

The CNSC is involved in emergency exercises with NPP licensees to ensure communication lines are in place and in a state of readiness. The federal departments also participate in provincial nuclear emergency exercises focused on emergencies originating at NPPs, in order to evaluate the transfer of information and deployment of federal resources.

In 2005, the CNSC participated in a full-scale exercise involving a simulated emergency at Darlington. Emergency Management Ontario, the Regional Municipality of Durham and OPG conducted the joint nuclear emergency exercise in November 2005. The City of Toronto, the City of Peterborough and federal agencies were also involved in supporting roles.

The aim of this exercise was to practise and evaluate some of the arrangements in place to respond to a nuclear emergency at Darlington. The exercise also provided an opportunity for OPG to evaluate its operational response capability pursuant to the regulatory requirements of the CNSC. The exercise achieved its goal and demonstrated that in the unlikely event of a nuclear emergency at Darlington, the emergency response organization, headed by the Province of Ontario, can respond effectively to protect the health, safety, property and environment of the citizens of Ontario.

The independent CNSC assessment concluded that OPG’s program and performance met or exceeded CNSC requirements. CNSC staff made some recommendations to which OPG responded with details of the dispositioning of each of the recommendations. The CNSC evaluation of the exercise also revealed several recommendations to improve emergency management at the CNSC.

In 2006, the Province of New Brunswick Emergency Measures Organization and NBPN conducted a joint exercise involving a simulated nuclear emergency at Point Lepreau. Additional participants included the Provincial Nuclear Emergency Control Group, Communications New Brunswick, Point Lepreau local area Wardens Service, and the Royal Canadian Mounted Police. The challenging exercise scenario was based on a sequence of events that led to two separate radioactive releases to the environment. The exercise proved to be a valid test of the NBPN response organization’s plans, procedures and training. The independent evaluation team found that the overall performance of the response organization met all required standards and displayed strength in many areas, such as:

- effective command and control within each group and timely and comprehensive briefings and situation updates;
- emergency response group shift rotation and turnover for effective multi-shift incident response coverage; and

- integration with off-site authorities and effective assessment and decision making regarding public protective actions.

The evaluation team found only small areas for improvement that required changes to procedures and training, in areas such as:

- information sharing and communication methods;
- awareness of roles and responsibilities of the various response groups and organizations; and
- emergency facilities and their available equipment.

The CNSC type II inspection of the full-scale emergency exercise at the Bruce Power site in 2006 concluded that Bruce Power demonstrated its ability to effectively manage and implement its emergency response. The problems encountered during the exercise were quickly resolved and the emergency organization demonstrated a capability for self-assessment and capture of opportunities for improvement.

As reported in the third Canadian report, in 2003, the CNSC and federal partners participated in the TOPOFF2 exercise to provide a training opportunity for top officials designated in national plans in Canada and the United States. The CNSC continues to support this series of exercises and expects to participate in the TOPOFF4 exercise scheduled for 2007.

As reported in the third Canadian report, in 2003, the CNSC and HC participated in the IAEA's Convex-2A exercise. The CNSC expects to participate in a Convex regional exercise with members from Canada, U.S. and Mexico in Mexico in 2008.

16.2 Provision of Information to Population of Canada and to Authorities of Neighbouring States

16.2 a Measures for Informing the Public During a National Nuclear Emergency

The FNEP describes overall coordination in the event of a national nuclear emergency in Canada. Information is to be provided at the national level to members of the media and the public through a central point of contact: the Public Affairs Group (PAG). The PAG serves as the federal coordination point for the collection, generation and distribution to the public and the news media of information concerning the emergency.

The PAG is made up of representatives of organizations that have defined responsibilities within the structure of the FNEP, along with other organizations and governments involved in a specific nuclear emergency.

16.2 b International Arrangements, Including Those with Neighbouring Countries

Canada participates in the International Nuclear Event Scale (INES) reporting system which is administered by the IAEA. The system uses a severity scale for use between countries to describe the safety significance of incidents and accidents.

Canada is a signatory of the following three international emergency response agreements:

Canada-US Joint Radiological Emergency Response Plan (1996)

This joint plan focuses on emergency response measures of a radiological nature rather than generic civil emergency measures. It is the basis for cooperative measures to deal with peacetime radiological events involving Canada, the United States, or both countries. Cooperative measures contained in the FNEP are consistent with the joint plan.

Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (1986)

Developed under the auspices of the IAEA, the purpose of the agreement is to provide for cooperation between signatories to facilitate prompt assistance in the event of a nuclear accident or radiological emergency to minimize its consequences and to protect life, property, and the environment from the effects of radioactive releases. The agreement sets out how assistance is requested, provided, directed, controlled, and terminated. This Convention has yet to be ratified pending a review of domestic implementing legislation.

Convention on Early Notification of a Nuclear Accident (1987)

Also developed under the auspices of the IAEA, this Convention defines when and how the IAEA should be notified of an event with potential trans-boundary consequences and when and how the IAEA would notify the signatories of an international event which could have an impact in their respective countries.

16.3 Provisions for Countries that Do Not Have Nuclear Installations

This part of Article 16 does not apply to Canada.

PART D
Safety of Installations

Part D of Chapter IV consists of three articles:
- Article 17 – Siting
- Article 18 – Design and Construction
- Article 19 – Operation

Article 17 – Siting

Each Contracting Party shall take the appropriate steps to ensure that appropriate procedures are established and implemented:

(i) for evaluating all relevant site-related factors likely to affect the safety of a nuclear installation for its projected lifetime;

(ii) for evaluating the likely safety impact of a proposed nuclear installation on individuals, society and the environment;

(iii) for re-evaluating as necessary all relevant factors referred to in sub-paragraphs (i) and (ii) so as to ensure the continued safety acceptability of the nuclear installation;

(iv) for consulting Contracting Parties in the vicinity of a proposed nuclear installation, insofar as they are likely to be affected by that installation and, upon request providing the necessary information to such Contracting Parties, in order to enable them to evaluate and make their own assessment of the likely safety impact on their own territory of the nuclear installation.

The initial stage of the licensing process for NPP in Canada is site acceptance as described in subsection 7.2 (ii) c. An environmental assessment (EA) must be carried out before the Commission can issue a licence to prepare a site. In addition, the CNSC cannot issue a licence unless it is satisfied that all necessary provisions to protect persons and the environment are in place. This includes a confirmation by the CNSC that the effects of the site on the proposed nuclear power plant (NPP) will also be acceptable.

A general list of information required with licence applications to the CNSC is provided in subsection 7.2 (ii) b. In particular, section 4 of the *Class I Nuclear Facilities Regulations* specifies the following information that must accompany an application for a licence to prepare the site (much of this information is also considered in the EA process):

- a description of the site evaluation process and of the investigations and preparatory work that have been and will be done on the site and in the surrounding area;
- the proposed program to determine the environmental baseline characteristics of the site and the surrounding area; and
- a description of the measures that will be taken to prevent or mitigate the effects on the environment and the health and safety of persons that may result from the activity to be licensed.

The CNSC's review of a site licence application follows the process shown in the figure in subsection 7.2 (ii) b. The submitted information is reviewed by CNSC staff and the federal and provincial environmental agencies for compliance with relevant regulations. Public information meetings, and the discussions that follow, also assist in judging the acceptability of the site. The information is assessed against the criteria described under sections 17 (i) and 17 (ii) below.

Note that the CNSC is currently developing new site evaluation requirements; see section 7.2 (i) for details.

As mentioned in Chapter II, Section D.4, two applications for licences to prepare NPP sites were submitted to the CNSC near the end of the reporting period. The applicants, Bruce Power and Ontario Power Generation, prepared project descriptions for the EA and CNSC staff initiated the processes described in this Article.

17 (i) Evaluating the Effect of the Site on Safety of NPPs

The criteria for evaluating the effect of the site on the safety of the NPP falls under two categories.

The first category includes demographics, ease of access/egress from the site and populated areas, site location with respect to electrical grid lines and the security of electrical connections. Easy access (availability of appropriate highways and bridges) is required to facilitate the movement of resources in the event of an emergency, shift crew rotation, emergency generator fuel oil delivery, fire and security response, and potential emergency response evacuation.

The second category addresses the site impact on the safety of the NPP. This includes the susceptibility to flooding (storm surge, dam burst, etc.), hurricanes, tornados, ice storms or other severe weather, and earthquakes. This category also includes 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); and
- military test ranges (possibility of stray missiles).

The licence applicant addresses these criteria in the site evaluation report, the results of which are also integrated into the safety report (discussed further under sections 17 (ii) and (iii)). The site evaluation report includes a description of the design of the NPP, and it identifies and assesses the site characteristics that may be important to the safety of the proposed NPP. The following elements are included in the report:

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

17 (ii) Evaluating the Effect of a Proposed NPP on Individuals, Society, and the Environment

The EA process is required to evaluate the effect of a proposed NPP on the environment. The licence applicant also conducts environmental risk assessments to determine the likely effects on the environment from their operations. The CNSC separately evaluates the licence applicant’s proposed measures to protect individuals, society, and the environment. A description of the environmental protection program is one of several submitted by licence applicants (see Appendix C) for review by CNSC staff.

17 (ii) a Environmental Assessment

The EA process is described in Annex 17 (ii) a.

The scope of the EA under the *Canadian Environmental Assessment Act* (CEAA) must include the following factors:

- the environmental effects of the project, including the environmental effects of malfunctions or accidents that may occur in connection with the project and any cumulative environmental effects that are likely to result from the project in combination with other projects or activities that have been or will be carried out;
- the significance of the effects identified above;
- comments from the public; and
- measures that are technically and economically feasible and that would mitigate any significant adverse environmental effects of the project.

With the discretion allowed for in the CEAA, the CNSC may also require consideration of these elements:

- the purpose of the project;
- traditional and local knowledge, where relevant;
- the need for, and requirements of, a follow-up program in respect of the project; and
- the capacity of renewable resources that are likely to be significantly affected by the project to meet the needs of the present and those of the future.

Extensive opportunities for public and stakeholder input are typically provided. These include a variety of proposed activities such as a Web site, open houses, workshops and written communications.

17 (ii) b Criteria for Evaluating the Safety Impact of the NPP on the Surrounding Environment and Population

The safety impact of the proposed NPP, under normal and accident conditions, is evaluated for both the surrounding environment and population. The impact on the environment is evaluated by examining the effects on the water supply, air quality, wildlife, lakes and rivers. Such evaluation criteria are identified in the EA guidelines and assessed by the applicant in the environmental impact statement that is produced to satisfy relevant provincial and federal laws (see Annex 17 (ii) a).

The safety impact on the population examines the population dose from postulated design basis events. Given that the NPP will perform as designed under accident conditions, it is important to consider population-related factors to meet radiation dose limits set by regulations. Such factors include the number, nature (subdivision, rural, industrial, school, hospital, etc.), and distribution of population around the facility. The applicant addresses these criteria in the safety report, which calculates the population doses and verifies that the NPP design meets its safety targets.

The CNSC also establishes criteria for licensee programs for radiation protection (includes dose control) and environmental protection (includes control of releases of hazardous substances).

17 (iii) Re-evaluation of the Safety Impact of the Site and the NPP

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 above is periodically verified. Possible changes to the site demographics, or significant changes to the understanding of local environment, include the following:

- discovery of new fault lines affecting seismicity at the site;
- changes to man-made neighbouring facilities such as a newly constructed oil refinery, rail corridor, airport flight path or chemical plant; and
- climate change.

Such changes must be examined through activities including regular reviews of emergency response measures, security measures, and the safety report (see subsection 14 (i) a). The safety report contains sections with the following information:

- demographics;
- weather experience;
- seismicity;
- neighbouring facilities; and
- air and rail transport corridor activity.

Each NPP licensee is required to submit an annual report to the CNSC detailing the results of environmental radiological monitoring programs, together with an interpretation of the results and estimates of radiation doses to the public resulting from NPP operations. The results from these monitoring programs are used to ensure the public legal limit in Canada for effective dose from the operation of NPPs is not exceeded.

17 (iii) b Results of Environmental Assessments for Life Extension Projects

Applying the EA process to refurbishment and life extension projects help ensure the continued operational safety of NPPs. The following briefly describes the status and results of EAs for life extension projects (refer to section D.3 in Chapter II and section 14 (ii) for other information on these projects).

An EA was completed for the Bruce A refurbishment project. The CNSC, as the responsible authority, determined that the project is not likely to cause significant adverse affects on the environment, taking into account identified mitigation measures.

For the Pickering B refurbishment project, the CNSC determined that an EA is required under the CEAA and has developed EA guidelines for a screening EA. Within the discretion allowed for in the CEAA, the CNSC is requiring consideration of the additional factors listed in subsection 17 (ii) a.

Following a one-day public hearing in January 2007, the Commission announced its approval of the EA guidelines for the Pickering B refurbishment. The Commission decided that it would not, at this time, refer the project to the federal Minister of the Environment for referral to a mediator or review panel. In accordance with the approved EA Guidelines, CNSC staff will prepare an EA screening report for the Commission's consideration at a future public hearing. If the Commission concludes from the screening report that the project is not likely to cause significant adverse environmental effects, taking into account the appropriate mitigation measures, the Commission may proceed to consider the related licence application.

In December 2006, the CNSC announced its conclusion that Hydro-Québec's proposed project for refurbishment for continued operation of Gentilly-2 to 2035 was not likely to cause significant adverse environmental effects, taking into account mitigation measures identified in the EA screening report.

17 (iii) c CNSC Assessment of Licensee Programs for Environmental Protection

CNSC staff regularly assesses licensees' environmental protection programs that protect the public and environment from releases of radioactive and hazardous substances. Under the CNSC safety area "Environmental Protection," the programs and their implementation were judged by CNSC staff to meet requirements during the reporting period (see Appendix G, Table G.3).

17 (iv) International Arrangements with Neighbouring Countries That Could be Affected by Nuclear Power Programs in Canada

Canadian legislation and process —and, in particular, the CEAA and its Regulations, and the federal EA and review process — do not oblige proponents of domestic NPPs that could affect the United States, to consult with United States jurisdictions or the American public regarding the proposed siting of the NPP. However, potentially significant effects from such proposals would be considered to their full geographic extent, regardless of political boundaries or borders.

In addition, the Government of Canada and the Government of the United States of America, in cooperation with state and provincial governments are obligated to establish programs to abate, control and prevent pollution from industrial sources. These programs include measures to control the discharges of radioactive materials into the Great Lakes system, by virtue of the Great Lakes Water Quality Agreement.

The CNSC and the U.S. Nuclear Regulatory Commission (USNRC) have a long practice of cooperation and consultation since the 1950s. In 1996, they entered into a bilateral administrative arrangement for "cooperation and the 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.

Introduction

The framework and process for issuing licences for nuclear power plant (NPP) construction are described in Article 7.

The following summarizes the provisions for the design and construction of existing CANDU NPPs in Canada. The first and second Canadian reports contain extensive information on the evolution of the design and construction of CANDU-type NPPs.

The CNSC "Equipment Fitness for Service" safety area consists of the following four licensee programs:
- maintenance;
- structural integrity;
- reliability; and
- equipment qualification.

A fuller description of this safety area is given in Table G.2 of Appendix G. The programs in this safety area contribute to the level of defence-in-depth of the NPP by helping to prevent accidents, maintain the integrity of the barriers to radioactive releases, and mitigate accidents. During the reporting period, CNSC requirements for programs were met by all NPPs, while requirements for implementation were met in almost all cases (see Table G.3 in Appendix G).

Applications for new reactors (see Section D.4 in Chapter II) could involve various reactor technologies. The CNSC is preparing for the assessment of those applications as well as is updating its regulatory document framework. The CNSC started to bring its design and safety analysis requirements in closer alignment with international standards, in particular with those promulgated through the IAEA. This has led to the development of new requirements for safety analysis and design (see subsection 7.2 (i) for details).

The CNSC participates in the Multinational Design Evaluation Program, which is considering the extent to which regulators can cooperate in evaluating reactor designs. This is a pilot project that is limited to a few technical areas. It compares the regulatory requirements from each participating country and the regulatory activities undertaken to verify that requirements have been met. The program aims at harmonizing regulatory requirements and regulatory practices. The group, which has representatives from 12 countries, is set up under the Nuclear Energy Agency (NEA).

18 (i) Defence-in-Depth

To ensure a low probability of failures or combinations of failures that would result in significant radiological consequences, design for the defence-in-depth approach considers the following concepts:

- conservative design and high quality of construction to minimize abnormal operation or failures;
- provision of multiple physical barriers for the release of radioactive materials to the environment;
- provision of multiple means for each of the basic safety functions (for example, reactivity control, heat removal, confinement of radioactivity);
- use of reliable engineered protective devices in addition to the inherent safety features;
- supplementing the normal control of the NPP by automatic activation of safety systems or by operator actions; and
- provision of equipment and procedures to detect failures and back up accident prevention measures in order to control the course and limit the consequences of accidents.

The Canadian approach to NPP safety evolved from the recognition that even well designed and well built systems may fail. However, when the defence-in-depth strategy is properly applied, no single human error or mechanical failure has the potential to compromise the health and safety of the persons, and the protection of the environment. Emphasis has been placed on designs that incorporate "fail-safe" modes of operation, should a component or a system failure occur. The approach also recognizes the need for separate, independent safety systems that can be tested periodically to demonstrate their availability to perform their intended functions.

During the reporting period, the level of defence-in-depth at all Canadian NPPs remained acceptable.

The following are some important examples of implementing the elements of the defence-in-depth approach for designing CANDU reactors.

18 (i) a Accident Prevention

The first and most important principle of defence-in-depth is accident prevention; that is, ensuring a low probability of operational failure of a system or component. This is accomplished by the following practices:

- applying sound engineering practices during the siting, design, construction and operation of an NPP;
- using proven technologies;
- designing, building and maintaining the NPP according to recognized codes and standards;
- ensuring plant staff are appropriately trained;
- employing appropriate quality control and QA methods in all phases of design, manufacturing, construction, and operation;
- performing periodic inspection and testing of components and systems; and
- monitoring events in other similar facilities to anticipate problems before they occur.

18 (i) b Barriers to Radioactive Releases

In CANDU design, most of the radioactive material resides in the fuel elements. There are five barriers between this material and the public, as enumerated in the following.

1. Uranium Oxide Fuel: The fission products are produced and trapped in the solid fuel matrix. More than 99% of them remain in the fuel and are never released under normal conditions. Only a fraction of 1% of these fission products escape the uranium oxide and are then contained within the fuel sheath.

2. Fuel Sheath: It retains the small amount of volatile fission products that escape the fuel matrix.
3. Heat Transport System (HTS): The fuel is contained in the HTS. An intact HTS retains the fission products even if sheath failures occur and the small amounts of fission products (usually known as free-gap inventory) that reside between fuel and the sheath are released.
4. Containment System: The next barrier to the releases is the containment system, which contains radioactivity if both the fuel sheath and the HTS fail.
5. Exclusion Zone: It provides atmospheric dilution of any fission product releases from the containment if all of the other barriers are breached.

In CANDU design (see first and second Canadian reports for details), the protective shutdown systems (SDS1 and SDS2), the emergency core cooling (ECC) system and containment system are combined into a single category of “special safety systems”. Canadian NPPs typically include additional protective equipment (separate from and independent of the special safety systems) to make sure there is an acceptably low frequency of challenges to the safety systems. Examples of such process-protective equipment involve the setback and stepback functions of the reactor regulating system, which are designed to cope with some reactor control failures without requiring action by the safety shutdown systems.

18 (i) c Redundancy

Redundancy is the use of two or more components or systems that are each capable of performing the necessary functions. System redundancy is achieved by having independent systems perform equivalent functions. In the CANDU “two group” design concept, two groups of selected safety-related systems are provided in the NPP, each of which can maintain the NPP in a safe state and perform the essential safety functions of NPP shutdown.

The NPP systems are divided into two basic groups as follows:

- **Group 1 Systems:** systems that provide a safety function to mitigate an event and that also perform a safety function or power production function during normal station operation. Group 1 includes these systems:
  - power production systems;
  - one group of special safety systems; and
  - a set of safety support systems.
- **Group 2 Systems:** systems that provide a safety function to mitigate an event and perform no function during normal station operation are allocated as Group 2 systems wherever possible. The following systems are included in Group 2:
  - the second group of special safety systems; and
  - a second set of safety-support systems.

Besides redundancy of the groups of systems, component redundancy is built in to the special safety systems to satisfy the single failure criterion. Special safety systems satisfy an unavailability target of 10^{-3}, which effectively requires redundancy of all critical components. Regular tests of special safety systems components verify the availability of these systems during operation. CNSC regulatory documents *Requirements for Containment Systems for CANDU Nuclear Power Plants* (R-7), *Requirements for Shutdown Systems for CANDU Nuclear Power Plants* (R-8), and *Requirements for Emergency Core Cooling Systems for CANDU Nuclear Power Plants* (R-9) specify safety design standards for special safety systems.

The first step in defining safety system design requirements is to identify the initiating events and event combinations that place the most severe demands on the systems. Generally, this involves a combination of judgement, knowledge of results of analyses of previous plants, and the selected scoping analyses. The selected initiating events are then analysed in detail.

In addition, CANDU NPPS are designed for dual failures, which consist of a design-basis initiating event along with coincident unavailability of one special safety system. This means that an NPP is designed, for example, to mitigate a LOCA combined with a loss of ECC injection by using the moderator system as an alternate means of fuel cooling.

Process systems also make extensive use of redundancy to improve station availability in the production of electrical power. This redundancy minimizes the frequency of serious process failures.

18 (i) d Diversity

Diversity is the use of two physically or functionally different means of performing the same function. It provides protection against certain types of common-mode failures, such as those arising from design or maintenance errors.

Providing two different shutdown systems for CANDU reactors is a good example of diversity. The design concept of system diversity is also used in the design of independent emergency cooling water and power systems provided via the two-group approach.

18 (i) e Separation

The separation of special safety systems from the systems used for power production (process systems) is a fundamental safety principle and a regulatory requirement in Canadian practice. It ensures that events affecting a limited area of the station and functional interconnections between systems do not impair the capability to perform required safety functions under accident conditions.

Separation refers to the use of barriers or distance to separate components or systems that perform similar safety functions. Therefore, if a failure or localized event occurs in or near one system or component, it is unlikely to affect the other. Separation provides protection against common-mode or cross-linked effects such as fires and missiles.

Physical and functional system separation is designed into the two-group concept in CANDU NPPs. The components of special safety systems that perform similar functions are separated to the maximum practicable extent, and redundant components within systems are physically separated according to their susceptibility and common hazards. Specific requirements are applied to the triplicated instrument cables and the duplicated power and control cables for safety-related systems. The odd and even concept of on-site power distribution is applied to equipment, the raceway system and junction boxes to maintain physical separation between the odd and even systems. This results in maximum reliability under normal and abnormal conditions.

18 (i) f Mitigation of Accidents

The defence-in-depth approach also requires provisions and procedures to be in place to mitigate the consequences of accidents. These include measures to prevent fuel failure following a serious process failure as well as provisions to contain radioactive materials in the event of fuel failures. Accident mitigation is achieved by incorporating:

- multiple barriers as described in subsection 18 (i) b;
- measures to protect these barriers from damage due to accidents; and
- reliable and effective special safety systems into the design that are capable of limiting the consequences of accidents.

Mitigation of accidents also includes building redundancy and diversity, to continue providing important safety functions, such as electric power and heat removal, even after some components have failed as a result of an accident. Examples of this include:

- the auxiliary steam-generator feed pumps, the shutdown cooling system and the emergency water systems, all of which are capable of removing heat from the reactor;
- a secondary control room, for use should the main control room be unavailable for any reason; and
- redundant electrical power supplies and service water supplies to essential equipment.

18 (ii) Proof of Technologies

The CANDU design criteria and requirements include design and construction of all components, systems and structures to follow the best applicable code, standard or practice and be confirmed by a system of independent audit.

Measures are embedded in the Canadian licensing process to ensure the application of state-of-the-art proven technologies. These measures are described in subsection 7.2 (ii) d. In each phase of licensing, documents have to be submitted to describe the technology employed, and to verify and validate it. These include the safety report and the QA program.

Tools and methodologies used in the safety report have to be proven according to national and international experiences and validated against relevant test data and benchmark solutions. During the reporting period, the GAI on “Validation of Computer Programs Used in Safety Analysis of Power Reactors” (GAI 98G02) was closed.

A Canadian licence requirement for an operating NPP is an updated safety report at least once every three years. The safety report must use or incorporate the following:

- new methodologies;
- computer codes;
- experimental data; and
- research and development findings.

As a result, many of the events in the safety report are often re-analysed in the updated version.

18 (iii) Consideration of Operability and Human Factors

Consideration is given to human factors and man-machine interface throughout the entire life of the NPP to make sure that stations are tolerant of human errors. Five examples are given below to illustrate where human factors and man-machine interface have been considered.

- A high level of automation is incorporated to reduce the risk of operator errors. For instance, automatic actuation of controls or protection systems was developed in order to respond to equipment failure or human error, which could cause a parameter to exceed normal operational limits or a safety system trip set-point. The overall design and the specific design of protection systems make sure that operator intervention is only required when there is sufficient time to diagnose plant conditions and to determine and implement operator actions.

- Control room design incorporates strategic placement of the instrumentation and controls used in safety-related operations and accident management. Specific attention is given to device grouping, layout, labelling and device selection. Appropriate attention to human factors and man-machine interface concerns ensures that the information available in the control room is sufficient to diagnose anticipated events or transients and to assess the effects of any actions taken by the operators.

- 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. Effective use of communication protocols minimizes the chances of human errors.
- 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.
- 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. Making sure employees are qualified and trained for their positions provides an additional barrier that minimizes the probability of human errors.

System alignment verifications and post-maintenance testing are routinely performed to detect and correct human errors that occur during system manipulation or maintenance.

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.

The most safety-significant operational events that occurred at Canadian NPPs during the reporting period are listed chronologically in Appendix D. None of these events posed a significant threat to persons or the environment. All were assessed as level “0” or “1” on the International Nuclear Event Scale (INES).

One of the performance indicators that licensees regularly report to the CNSC is “unplanned capability loss factor.” This is the percentage of the reference NPP electrical output lost due to unplanned circumstances. During the reporting period, the average value of the performance indicator for the industry decreased slightly: it was 9.6 in 2004, 8.2 in 2005, and 8.0 in 2006.

The following table provides values of the performance indicator “Number of Unplanned Transients” for the reporting period. This performance indicator is the number of manual or automatic power reductions from actuation of the shutdown, stepback, or setback systems.

Trend Details of Number of Unplanned Transients for Industry

Year	Number of Unplanned Transients in Industry			
	Trips	Stepbacks	Setbacks	Total
2003	19	13	11	43
2004	10	5	22	37
2005	13	5	35	53
2006	9	7	22	38

The number of transients has also been declining in recent years, especially the number of reactor trips, despite the fact that two units at each of Bruce A and Pickering A were brought back on line from 2003 to 2005.

These performance indicator results provide a general indication of the licensees' ability to maintain and enhance event-free operations during the reporting period.

Three of the safety areas for which CNSC staff rates licensees programs and implementation are relevant to this article:

- "Operating Performance" includes topics that are relevant to overall safety and operations;
- "Design and Analysis" includes topics that are related to the conduct of safety analysis and the use of the results; and
- "Equipment Fitness for Service" that covers maintenance programs.

Table G.2 in Appendix G provides a fuller description of these safety areas. In all three safety areas, licensees generally met the CNSC's requirements and expectations for both the programs and their implementation during the reporting period (see Table G.3 in Appendix G).

19 (i) Initial Authorization to Operate a Nuclear Power Plant

There were no initial licensing activities related to operating a new NPP during the reporting period.

The initial authorization to operate a NPP is based upon an appropriate safety analysis and a commissioning program, which must demonstrate that the NPP, as constructed, meets design and safety requirements. It is given that all regulatory requirements regarding siting, design and construction, as outlined in Articles 7, 17 and 18, will have been met.

As stated under subsection 7.2 (ii) e, before issuing an operating licence, the CNSC must be assured that:

- the construction of the NPP conforms to the design submitted and approved;
- the safety analysis is complete; and
- the plans for operation are satisfactory.

Before an NPP is commissioned, several CNSC staff members are located at the NPP site to observe and report on the commissioning and start-up processes and activities.

The CNSC staff does not attempt to participate in all aspects of a licensee's commissioning program. Rather, reliance is placed on the licensee's internal review process, which is mandated by the commissioning QA. Detailed commissioning specifications define the acceptance criteria to be used in inspections and tests done as part of the commissioning program. Typically, the licensee's procedures require the designers to approve commissioning specifications for a particular system or component that:

- the program is checking the right items; and
- the acceptance criteria being used are appropriate to prove that the equipment can perform the safety functions intended in the design.

The commissioning QA plan also requires the process of approving the specifications and results to be documented. Any failure to meet the acceptance criteria must be referred back to the design organization, which will decide what, if any, design changes are required. This allows the CNSC staff to perform inspections, at any time, to confirm that procedural requirements are being complied with; and that decisions made are appropriate.

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 (for example, a test of the plant's response to a loss of normal electrical power supplies). CNSC staff also witness major commissioning tests of special safety systems, such as functional tests of the shutdown systems where the reactor is actually tripped and the rate of power reduction is measured (and compared to the rate assumed in safety analyses).

In other cases, partial tests are done since complete tests are not practical (as in the case of commissioning tests of emergency core cooling systems). For example, while commissioning tests were done involving injection of emergency coolant into the reactor core, tests were not attempted in which cold water is injected into a hot core, for such tests could lead to high stresses in the primary coolant system components. The components are designed to withstand these stresses during a limited number of emergencies, but exposing them to such high stresses simply for testing purposes could not be justified.

When reviewing commissioning, CNSC staff concentrates on these major tests because they are considered particularly important to safety. These tests check the overall performance of an NPP's safety features and can reveal problems that tests of individual components would not detect. CNSC staff also reviews test proposals, including the detailed commissioning specifications, which are examined to confirm that tests' acceptance criteria are consistent with the system's safety design requirements as defined in the licence application. When tests are completed, CNSC staff reviews the test results and commissioning reports.

The CNSC requires the licensee to submit commissioning completion assurances before the first loading of fuel, first loading of heavy water, and the first criticality of the reactor. Commissioning completion assurances are written certifications with the following statements:

- Commissioning has been completed according to the process described in the licence application; and
- Commissioning results were acceptable.

Typically, the licensee holds a series of commissioning completion assurance meetings to review the work done on particular systems. The CNSC staff at site attends some of these meetings.

The completion assurance statements may contain lists of tasks not yet completed, including tasks such as completion of commissioning reports that are not prerequisites to the approvals being sought. These lists of incomplete items are helpful to ensure that these tasks are not subsequently overlooked.

19 (ii) Operational Limits and Conditions

19 (ii) a Identification of Safe Operating Limits

Operating limits for Canadian NPPs that have the greatest impact on safety are identified in the operating policies and principles (OP&P; see Article 9) documentation for Canadian NPPs. Changes to these limits require appropriate justification by operations support staff and approval by the CNSC.

The full set of requirements for safe operation of a CANDU NPP includes the following:

- requirements on special safety systems and safety-related standby equipment or functions (for example, setpoints and other limiting parameters, availability requirements);
- requirements on process systems (for example, limiting parameters, testing and surveillance principles and specifications, performance requirements under abnormal conditions); and
- 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 report. The safety analysis examines the NPP's responses to disturbances in process function, system failures, component failures and human errors. Other requirements (for example, those identified through design support analysis or PSA) could include limitations related to equipment and materials, operational requirements, equipment ageing, instrumentation and analysis uncertainties, etc. Assessments of failure modes and effects analysis can also identify requirements that form part of the safe operating limits. In principle, the analysis considers all allowable power levels and operating states. However, it is not feasible to analyse in advance every potential state that could occur throughout the life of an NPP. Therefore, the analysis attempts to consider sufficient situations to define safe operating limits that encompass the expected variations in conditions at a reasonable level of system/equipment performance detail.

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 Section 19 (iv)), as well as in the OP&Ps.

19 (ii) b Safe Operating Envelope Project

It was recognized in the early 1990s that safe operating limits for Canadian NPPs were not defined clearly enough in terms that were readily measurable by operations staff. Thus, significant additional support was needed from engineering and analysis staff for off-normal operations. Consequently, Canadian NPPs initiated improvement projects to provide better coordination of design and analysis limits in terms that operations staff could readily monitor and control. Initially, these improvements took the form of two separate projects, one undertaken by OPG and Bruce Power, and a separate project for CANDU-6 reactors in which NBPN and Hydro-Québec participated. Several stages of scope review and trial implementation improved the definitions of the safe operating limits as well as the impairments manual and maintenance practices for special safety systems.

Discussions among Canadian NPP licensees revealed that they were addressing issues differently, with varying degrees of success. It was decided that a cooperative project may be beneficial, and a COG project was initiated in 2001 to develop industry principles and guidelines for safe operating envelope (SOE) and to integrate best practices and operating experience (OPEX) from CANDU-6 NPPs and Ontario NPPs. The guidelines were published in 2003 and included the following definition of the SOE: "*The term safe operating envelope refers to the set of limits and conditions within which the nuclear generating station must be operated to ensure conformance with the safety analysis upon which reactor operation is licensed and which can be monitored by or on behalf of the Operator and can be controlled by the Operator.*"

The progress of the licensees on their individual SOE projects is described below. Those activities satisfied Action #10 on Canada that was assigned at the Third Review Meeting of the Convention to continue the SOE projects.

<u>Operational Safety Requirements</u>

OPG and Bruce Power have prepared or are preparing operational safety requirements documents for some safety-significant systems. These documents provide a comprehensive list of the limits for operation of a given system. The documents provide a definitive and maintainable link between safety analysis and operating documentation.

<u>Ontario Power Generation</u>

The SOE project is nearing completion at all three OPG NPPs. The project includes preparing detailed operation safety requirements and instrument uncertainty calculations documents to ensure compliance with the safety analysis. The project also includes a gap analysis to ensure that the current operating, maintenance and surveillance documentation are consistent with those requirements. Discrepancies are being dispositioned using normal change control processes such as engineering change control, document revision, and safety report update. No serious discrepancies were discovered.

Point Lepreau

NBPN recently revised the scope of its SOE project to align it with the COG guidelines, following the decision announced in 2005 to refurbish the plant for extended operation. This new project comprises two phases: the first phase will review and re-define the SOE for special safety systems, and the second phase will follow this through with application to other systems important to safety.

The first phase, intended to be complete in 2009, will comprise the following activities:
- revision of the Point Lepreau SOE methodology document for consistency with the COG project document;
- revision of SOE basis documents for ECC, SDS1, SDS2;
- completion the SOE basis document for containment;
- investigation with operations options for changes to the impairments manual approach and layout;
- implement the SOE for four special safety systems; and
- establish a processes to maintain the SOE.

Hydro-Québec

In early 2008, Hydro-Québec will write a document taking into account the COG guidelines for SOE for the revision of operating documents. A decision on the Gentilly-2 refurbishment is expected by the end of 2008. If the decision to refurbish for continued operation is taken, the second phase of the project will be implemented.

Bruce Power

The Bruce Power SOE project is focused on documentation and implementation of operational safety requirements for special safety systems as well as fuel and physics. The final implementation is targeted to be complete in 2008 to 2009. Implementation of the remaining systems important to safety will be reviewed starting in 2008. SOE requirements for Units 1 and 2 restart licensing are included as part of the scope of the current project.

19 (iii) Operation, Maintenance, Inspection and Testing of NPPs

Operation, maintenance, inspection and testing of systems, equipment and components at NPPs are conducted in accordance with approved governance and procedures. The governance for these defines the organizational and administrative requirements to establish and implement preventive, corrective and predictive maintenance, periodic inspections, tests, repairs, replacements, training of personnel, procuring spare parts, providing related facilities and services, and generating, collecting and retaining operating and maintenance records. All NPP operating licences contain conditions that specify the requirements for these activities.

One licence condition requires the licensee to establish and implement a maintenance program that includes inspection and testing. In particular, the licensee must ensure that the reliability and effectiveness of all equipment and systems continue to meet the standard claimed in the safety report and in the documents submitted as part of the application for a licence to operate.

One condition states that the licensee shall operate and maintain the facility according to methods and procedures and within the limits described in the OP&Ps. This document outlines the boundaries for safe operation and maintenance. It includes specifics for such things as special safety system availability and testing, maintenance, activity limits and precautions, monitoring and inspection.

Another licence condition establishes reliability program requirements by reference to CNSC regulatory standard *Reliability Programs for Nuclear Power Plants* (S-98 Rev 1). S-98 specifies that a reliability program for an NPP shall:

- identify all systems important to safety;
- specify reliability targets for those systems;
- describe the potential failure modes of those systems;
- specify the minimum capabilities and performance levels of those systems needed to satisfy regulatory requirements and the safety targets of the NPP;
- provide input for the maintenance program to maintain the effectiveness of those systems;
- provide for inspections, tests, modeling, monitoring, and other measures to assess the reliability of those systems;
- include provisions to assure, verify, and demonstrate that the program is implemented effectively;
- document the elements of the program; and
- report the results of the program.

Identification of "systems important to safety" is done using input from PSAs (see subsection 14 (i) d), deterministic analyses (see subsection 14 (i) a), and expert panels.

Maintenance and testing procedures for special safety systems must also meet the requirements set out in the OP&P document. These procedures are designed to make sure that no safety function is ever compromised by maintenance activities. Safety system testing is required at a frequency that demonstrates that each safety function is operating correctly and that each system has an availability factor of 99.9%. Each component of a special safety system is subject to a regular functional test.

19 (iv) Responding to Anticipated Operational Occurrences and Accidents

It is recognized that the consequences of reactor accidents can be minimized by sound accident management on-site and off-site. This is achieved by developing operating procedures in advance to assist and guide operators in responding to accidents. These procedures include generic emergency operating procedures, should the operators have problems diagnosing the accident, and training the operators in the use of these procedures by means of simulators and other techniques.

Procedures are established for responding to anticipated operational occurrences (AOOs) and accidents.

The response to AOOs and accidents is controlled through a hierarchical system of station procedures. Although procedure variations exist between stations, the generic structure of this system is summarized as follows:

- operating manuals;
- alarm manual;
- abnormal incident manual;
- impairments manual; and
- radiation protection manual (or radiation protection directives).

Procedures used by the NPP operations staff during routine operation of the NPP and its auxiliaries are located in the operating manuals. There are typically two categories of procedures within the system operating manual:

- system-based procedures that control operation of station systems during normal and abnormal operations, and system start-up and shutdown; and
- integrated procedures that coordinate major station evolutions such as station start-up and shutdown.

Alarm manual procedures provide the operations staff with information regarding alarm functions. Typical information provided within these procedures includes set points, probable cause of alarm, pertinent information, references and operator response.

Abnormal incident manual procedures provide information to the operations staff that may be helpful following safety system impairment, process system failure or a common mode event. At OPG, there are three categories of procedures within the abnormal incident manual:

- abnormal state of safety system procedures;
- emergency operating procedures; and
- critical safety parameter monitoring procedures.

At other utilities, abnormal plant operating procedures and emergency operating procedures are issued as separate manuals.

The procedures for abnormal state of safety systems direct compensatory actions to be taken when a safety system is impaired or unavailable. The emergency operating procedures direct operator actions during accident conditions and are designed to restore the station to a safe condition and to protect the health and safety of station personnel and the general public. Critical safety parameter procedures provide augmented monitoring of critical station operating parameters during accident conditions and provide a support feature to the emergency operating procedures (see subsection 16.1 b for on-site emergency procedures).

Impairment manual procedures specify actions to be taken when there are indications that operation is getting close to or outside the safe operating limits.

Radiation protection manual procedures are provided to protect the safety of the operators and the general public in the event of a significant radiation incident. These procedures:

- direct event classification and categorization;
- make provisions for off-site notification; and
- direct protective actions and monitoring during accident conditions.

An operating licence condition specifies the minimum staff complement that must be present at the station at any time. The CNSC includes this requirement to make sure that there is always a sufficient number of appropriately qualified staff available to respond to an emergency (for details, see Annex 11.2 a).

The fundamental elements of licensee procedures for responding to anticipated occurrences and events were unchanged during the reporting period. Some adjustments, however, were made to licensees' procedures due to the introduction in 2003 of the CNSC standard S-99 (see subsection 7.2 (iii) c). In general, and as described in the second and third Canadian reports, licensees have developed and continue to maintain operating procedures for dealing with operational occurrences, situations and events. Such procedures include determination of root causes and effecting remedial and corrective actions commensurate with the situations. The examples of operational events in Appendix D illustrated how the licensees responded to the events and how the CNSC followed up.

Severe Accident Management Guidelines

The Canadian NPP licensees took steps in 2002 to form a Severe Accident Management working group, coordinated by COG, with the objective to formulate severe accident management guidelines (SAMG) for CANDU reactors based on international best practices. Emergency operating procedures at that time addressed a number of accident situations well beyond design basis accidents; however, they tended to focus on the use of equipment and systems within the scope of their intended purpose and within the constraints of normal operating rules. The Severe Accident Management project is intended to extend the scope of severe accident management beyond these procedures, in the event that significant core damage occurs or is imminent, to take all reasonable measures with any available equipment in attempts to mitigate core damage and releases from containment.

In parallel with the first phase of the COG SAMG project, CNSC published a regulatory guide *Severe Accident Management Programs for Nuclear Reactors* (G-306) in 2006.

The first phase of the COG SAMG project concluded early in 2007. It adapted the Westinghouse Owners Group approach to severe accident management for use in CANDU reactors, producing a set of generic guidelines applicable to all operating CANDU models, and then a more focused set of guidance documents for each of the CANDU models (CANDU-6, Pickering and Bruce/Darlington). The COG brought the project to the attention of overseas members, providing the opportunity for all CANDU-6 reactor operators to participate in and benefit from information developed during the project.

The second phase of the Severe Accident Management project, also coordinated by a COG working group, will see the implementation of the project documents by the utilities, adapting the SAMG strategies and guides to each specific site and operating organization, interfacing the SAMG with the control room emergency operating procedures, validating the SAMG documentation against a wide variety of scenarios, and providing the emergency response organization with training necessary to implement severe accident management strategies during emergencies. Exercises to verify the effectiveness of the developed strategies and documentation will focus initially on potential core damage scenarios identified by probabilistic safety assessments as constituting the highest residual risk. This implementation phase commenced in early 2007 and is expected to be at the stage of implementation validation exercises for various plants during late 2008 to 2010.

Follow-up at Pickering to the Loss of Electricity Grid (Blackout) of August 14, 2003

As reported in the third Canadian report, follow-up to the loss of the electricity grid (blackout) on August 14, 2003, at Pickering identified that some of the design and operation assumptions could be challenged by such an event. In particular, the high-pressure ECC system, which is common to both Pickering A and B, was unavailable for 5.5 hours because of loss of power to the high-pressure pumps. In addition, the emergency high-pressure service water system restoration for all Pickering B units was delayed because of low suction pressure supplying the emergency high-pressure service water pumps. During that time, there was no fire water available to Pickering B. During the loss of off-site power, the three units at Pickering B remained in a hot, pressurized state with heat removal through the steam generators via thermo-syphoning. The CNSC requested that OPG identify potential changes in facility design, analysis, testing and maintenance to mitigate future occurrence of the results observed.

To address the need for power to enable the cooling of the units, a major design change was initiated at Pickering to install an auxiliary power system. In the interim, while the auxiliary power system is being installed, a temporary 22 MW remotely switched emergency power generator was put in place to assure a quick recovery for any future blackout event.

The auxiliary power system has two 45-MW combustion turbine units to supply power during a blackout by delivering it directly to the NPP electrical system. Design of the auxiliary power system power plant was completed in 2006 and the project is in mid-construction. Work is on schedule to have the system ready for use in 2007.

Modifications have been completed to the turbine-generator control systems to improve the likelihood of the units continuing to operate after a similar event.

The remaining issues from the loss of the electricity grid in 2003 are related to service water supply capacity, service water surveillance and maintenance, and fire water supply capacity. OPG has improved the service water system capacity by refurbishing all emergency high- and low-pressure service water pumps on Unit 7. The same pumps on Unit 5 were being overhauled and the remaining overhauls are scheduled for planned outages. OPG has also completed and submitted the operational safety requirements document for the service water systems. This document showed that the service water systems are able to meet all their capability requirements. Work is still underway to completely resolve the fire water capacity issue.

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 (for example, AECL) that include research, engineering, analysis, assessment, maintenance, inspections and design support. The R&D program for CANDU that supports the operating NPPs is described in Appendix E.

19 (vi) Reporting Incidents Significant to Safety

In 2003, the CNSC introduced an updated standard (S-99) for reporting requirements of operational situations and events (see subsection 7.2 (iii) c). Licensees modified their procedures accordingly and continued to report all safety-significant operational situations to the CNSC as per the S-99 requirements. S-99 also requires periodic reporting of non-significant situations, because their cumulative effect may indicate emerging performance issues.

19 (vii) Programs to Collect and Analyze Information on Operating Experience

Licensees conduct analysis and trending of events with relatively small safety significance in order to help prevent the occurrence of events with more significant consequences. A description of the programs to collect and analyze information on operating experience is provided in Annex 19 (vii).

Problems or issues that arise from event reviews that may be applicable to other stations are identified and brought to the attention of CNSC site inspectors and different specialist groups in the CNSC. They use this information to determine the appropriate course of action and assess the licensee's submissions regarding the particular event.

CNSC staff incorporates results of event analyses in their reviews and assessments of a licensee's corrective actions in response to a certain event. Where corrective actions undertaken by the licensee are considered inadequate, further actions are requested. In addition, the CNSC site inspectors review the status of corrective actions to make sure that they are completed expeditiously.

CNSC inspection teams consult the operating experience in a CNSC database (described in Annex 19 (vii)) when planning strategies for their audits and in identifying problem areas in operation or maintenance, such as procedural non-compliance, procedural deficiencies and use of non-standard components. Similarly, assessments conducted by CNSC specialists often utilise the operating experience recorded in this database.

19 (viii) Minimum Generation of Radioactive Waste

Responsibility

The Government of Canada has established a radioactive waste policy framework to ensure the safe management of spent fuel and radioactive wastes. Primary responsibility for the management and long-term storage of radioactive waste and spent fuel rests with licensees.

Operations

Canadian NPP operators manage 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 of CNSC regulatory policy *Managing Radioactive Waste* (P-290) is that generation of radioactive waste should be minimized to the extent practicable by implementing design measures and operating and decommissioning practices.

The Canadian nuclear industry minimizes waste through the following practices:

- material control procedures to prevent materials from unnecessarily entering into radioactive areas;
- enhanced waste monitoring capabilities to reduce inclusion of non-radioactive wastes in radioactive wastes;
- use of launderable personal protective equipment instead of single-use items;
- improvements to waste handling facilities; and
- employee training and awareness.

All waste produced at NPPs is segregated at its point of origin as contaminated or non-contaminated. Low-level and intermediate-level contaminated wastes are further sorted into distinct categories, such as the following:

- can be incinerated;
- can be compacted; and
- cannot be processed to reduce the volume further.

Further sorting of the waste helps to facilitate subsequent handling, processing and storage.

Radioactive Waste Management

Because there are no disposal facilities in Canada, all radioactive waste from NPPs is in interim storage. Radioactive wastes resulting from reactor operations are stored on-site or off-site 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.

Operators have instituted methods to recover storage space after sufficient radioactive decay or reclaiming existing storage space through further compaction (super compaction) and/or segregation.

It is possible to retrieve all stored radioactive waste.

Information on Canada's provisions for low- and intermediate-level waste and spent fuel can be found in the second *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 2005. This report is available on the CNSC Web site.

APPENDICES

Appendix A: Relevant Web sites

Document or Organization	**Web site**
Nuclear Safety and Control Act	http://laws.justice.gc.ca/en/showtdm/cs/N-28.3
Canadian Environmental Assessment Act	http://www.ceaa-acee.gc.ca/013/intro_e.htm
General Nuclear Safety and Control Regulations	http://laws.justice.gc.ca/en/n-28.3/sor-2000-202/153798.html
Class I Nuclear Facilities Regulations	http://laws.justice.gc.ca/en/n-28.3/sor-2000-204/153624.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 Owners' Group (COG)	http://www.candu.org
CANTEACH	http://canteach.candu.org
Department of Justice Canada	http://laws.justice.gc.ca
Health Canada (HC)	http://www.hc-sc.gc.ca
Hydro-Québec (HQ)	http://www.hydroquebec.com
International Atomic Energy Agency (IAEA)	http://www.iaea.org
New Brunswick Power Nuclear (NBPN)	http://www.nbpower.com
Natural Resources Canada (NRCan)	http://www.nrcan-rncan.gc.ca
Ontario Power Generation (OPG)	http://www.opg.com
Services Québec [PMUNE-G2]	http://www.urgencenucleaire.qc.ca
University Network of Excellence in Nuclear Engineering (UNENE)	http://www.unene.ca

Appendix B: List and Status of Nuclear Power Plants in Canada

Reactor[1]	Licensee	Gross Capacity MW	Construction Start	First Criticality	Operating Status
Bruce A, Unit 1	Bruce Power	904	June 1, 1971	Dec. 17, 1976	Defuelled: Dec. 31, 1997; being refurbished
Bruce A, Unit 2	Bruce Power	904	Dec. 1, 1970	Jul. 27, 1976	Defuelled: Oct. 8, 1995; being refurbished
Bruce A, Unit 3	Bruce Power	904	July 1, 1972	Nov. 28, 1977	Operating
Bruce A, Unit 4	Bruce Power	904	Sept. 1, 1972	Dec. 10, 1978	Operating
Bruce B, Unit 5	Bruce Power	915	July 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	Sept. 1, 1981	Nov. 5, 1989	Operating
Darlington, Unit 3	OPG	935	Sept. 1, 1984	Nov. 9, 1992	Operating
Darlington, Unit 4	OPG	935	July. 1, 1985	Mar. 13, 1993	Operating
Gentilly-2	HQ	675	Apr. 1, 1974	Sept. 11, 1982	Operating
Pickering A, Unit 1	OPG	542	June 1, 1966	Feb. 25, 1971	Restarted in 2005
Pickering A, Unit 2	OPG	542	Sept. 1, 1966	Sept. 15, 1971	Progressing toward safe storage state
Pickering A, Unit 3	OPG	542	Dec. 1, 1967	Apr. 24, 1972	Progressing toward safe storage state
Pickering A, Unit 4	OPG	542	May 1, 1968	May 16, 1973	Operating
Pickering B, Unit 5	OPG	540	Nov. 1, 1974	Oct. 23, 1982	Operating
Pickering B, Unit 6	OPG	540	Oct. 1, 1975	Oct. 15, 1983	Operating
Pickering B, Unit 7	OPG	540	Mar. 1, 1976	Oct. 22, 1984	Operating
Pickering B, Unit 8	OPG	540	Sept. 1, 1976	Dec. 17, 1985	Operating
Point Lepreau	NBPN	680	May 1, 1975	July 25, 1982	Operating

1. All operating reactors are pressurized heavy water reactors

Appendix C: Examples of Program Descriptions Required to Support a Nuclear Power Plant Licence Application

- Chemistry control program
- Community relations program
- Configuration management and change control program
- Corrective action and operating experience program
- Decommissioning plan and financial guarantees
- Effluent and environmental monitoring program
- Environmental protection program
- Emergency preparedness program
- Environmental qualification program
- Fire protection program
- Human factors program
- Maintenance program
- Nuclear substance control program
- Occupational health and safety program
- Organization staffing and training program
- Periodic and in-service inspection program
- Quality assurance program
- Plant life assurance program
- Radiation protection program
- Safeguards program
- Safety report and safety analysis program
- Security program
- Station improvement program
- System testing program
- Technical surveillance and reporting program
- Waste management program

Appendix D: Significant Events During Reporting Period

NPP **Date** **Topic**	**Description**	**Corrective Action by Licensee**	**Regulatory Action by CNSC**
Darlington February to December 2004 Openings in Steam-Protected Rooms	Several steam-protected rooms were found to have openings greater than the allowable size assumed in the safety analysis. Over several months, many more gaps were found.	OPG inspected all safety significant steam protected rooms. Repairs were completed to all rooms identified as needing repairs. Independent verification of 40 rooms was carried out to confirm the effectiveness of the gap identification. About 150 non-destructive and 10 destructive tests of repairs were conducted to give added assurance of the integrity of the repairs. Leakage testing of three steam-protected rooms has been completed to provide a more definitive confirmation that all significant gaps were found and repaired. The selected steam protected rooms will be retested periodically to monitor the degradation of their associated steam protection features.	CNSC staff actively monitored OPG's progress on this issue. Oversight included witnessing initial inspections, inspecting repairs, witnessing non-destructive and destructive testing of repairs, and witnessing independent verification inspections.
Pickering A Unit 4 Dec 2004 Loss of Class IV Power	While the reactor was returning to full power following an outage, the class IV power was lost and resulted in a reactor trip. The unit was placed in guaranteed shutdown state. The event was caused by a line fault on one of the transmissions lines while another was removed for service.	Corrective actions to the event include improvements to preventive maintenance programs and procedures.	CNSC staff was satisfied with the response of the unit and OPG staff during the incident.
Bruce B Unit 6	The unit shut down following an electrical fault and fire on the main	Bruce Power cleaned up the spill. Most of the oil was either recovered	As this was a conventional spill, it fell under provincial jurisdiction. The

NPP **Date** **Topic**	**Description**	**Corrective Action by Licensee**	**Regulatory Action by CNSC**
April 2005 Electrical Fault and Transformer Fire	output transformer. This led to a biodegradable mineral oil spill in Lake Huron. The fire was extinguished and there were no injuries.	or absorbed by the sand and gravel beneath the transformer. Hydro One crews replaced the transformer and the unit was returned to service. As a result of this event, secondary containment systems were installed for all outdoor transformers at the Bruce Power site.	Ontario Ministry of the Environment followed up with the licensee. No regulatory action was required by the CNSC.
Pickering B Units 7,8 June 2005 Standby Generators Unavailable	Due to independent failures of two of the three standby generators that supply Units 7 and 8, all three generators were unavailable for 5.5 days.	The causes for failure for the 2 stand-by generators were identified and the generators were repaired, tested and returned to service. During the time when all three standby generators were unavailable the Class III power system did not meet its design intent. Corrective actions taken included: • timely completion of planned standby generator upgrades • better prioritization of maintenance work • timely procurement of parts with the correct quality level for safety-related equipment	CNSC staff performed a risk significance assessment and concluded that an important layer of defence was lost during the event. An electrical systems inspection was completed in March 2006.
Pickering B Units 5,6,8 Aug. 2005 Shutdown of Units	Three of the four operating units were shut down due to wind conditions that resulted in a large influx of algae to the screen house.	Corrective actions taken include: • installation and testing of a barrier system to reduce algae influx to the station • improvement to the ability to monitor lake conditions and predict potential algae runs	

NPP Date Topic	Description	Corrective Action by Licensee	Regulatory Action by CNSC
		• improvements to screen house maintenance • improvements to operating procedures for responding to such events	
Bruce A Unit 3 September 2005 Loss of Regulation	A component malfunction caused a loss of regulation that was terminated by both shutdown systems. This transient occurred when reactor power increased and both shutdown systems as well as the reactor regulating system operated to shut down the reactor. No radioactivity was released. The event posed no risk to public health and safety.	Once the direct cause was well understood and the corrective actions were identified, the licensee took similar actions on the other operating Bruce A unit. A root-cause analysis was performed and determined to be a known design problem that had been allowed to persist. The design problem has subsequently been corrected on both Units.	Immediately after the event, CNSC staff informed other licensees of the event in order for them to examine the implications for their reactors. CNSC staff independently verified the facts of the event and assessed the adequacy of the root-cause analysis. CNSC staff was satisfied that Bruce Power correctly identified the direct cause and root cause and took appropriate corrective action.
Gentilly-2 March 2006 Station Alert	Failure in the process of transferring fuel from the reactor resulted in the release of radioactivity in the building. The licensee activated its emergency response plan and evacuated the reactor building. Hydro-Québec staff resolved the incident.	Corrective actions identified in the detailed event report submitted by Hydro-Québec include modifications to applicable procedures and increased ventilation system configuration testing.	CNSC staff on site monitored Hydro-Québec’s response and was satisfied that that licensee responded effectively and took all reasonable precautions to protect health, safety and the environment. CNSC continues to monitor Hydro-Québec’s completion of the corrective actions.

Appendix E: Research in Canada Related to Nuclear Power Plants

Nuclear Design and Research in Canada

AECL is developing an ACR-1000 reactor design, evolved from its in-depth knowledge of CANDU structures, systems, components, and materials, as well as the experience and feedback received from owners and operators of CANDU NPP. The ACR design features major improvements in economics, inherent safety characteristics, and performance. AECL is pursuing opportunities to build an ACR.

Natural Resources Canada also supports a Generation IV program to develop a super-critical water-cooled reactor and a very-high-temperature reactor. The Generation IV International Forum (GIF) has been established and GIF committees have been formed.

The following subsections describe supporting nuclear power plant research in Canada, the primary focus of which is on the CANDU design.

CANDU Owners' Group (COG) Research and Development Program

The COG research and development (R&D) program addresses current and emerging operating issues to support the safe, reliable and economic operation of CANDU reactors in the areas of fuel channels, safety and licensing, health, safety and the environment, chemistry, materials and components, and the Industry Standard Toolset.

The COG R&D program is co-funded by domestic CANDU licensees, Romania and AECL. COG R&D funding has shown an increased multi-year commitment, ranging from $29 million in 2002–03 to $38 million in 2007–08. 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.

<u>Fuel Channels</u>

- hydride blisters, diametral expansion, deuterium ingress, flaw assessment, fitness-for-service guidelines, and assessment of pressure tube life.

<u>Safety and Licensing</u>

- Large LOCA margins: addressing power pulse uncertainties, fuel channel behaviour and high-temperature fuel behaviour, specifically to restore operating and safety margins associated with predicted power pulses postulated for predicted large loss of coolant events
- Fission product source terms: addressing hydrogen behaviour in containment, fuel and fission product behaviour in accidents and iodine issues, specifically to address issues associated with discharges of hydrogen and steam for a postulated loss of coolant event with postulated loss of emergency core coolant injection.
- Trip effectiveness criteria: addressing Critical heat flux, bundle void and flow quality, and shutdown system characterization, specifically to improve the accuracy and computational efficiency of thermohydraulic codes used in licensing analysis and to improve the quantification of shutdown system operating and safety margins
- Single channel severe overheating events: addressing molten fuel moderator interaction experiments, specifically to address the issues associated with postulated discharges of molten fuel into the moderator, following a severe loss of coolant in a fuel channel, and the potential for further consequential damage to the reactor
- Safety analysis technology: addressing advanced analysis methodologies

- Fuel design and performance: addressing generic fuel related postulated initiating events, normal operating condition technologies and the impact of fuel conditions on safety
- Plant ageing and life extension: addressing safety issues associated with ageing, specifically to address improved quantification of the impact of heat transport system and reactor core ageing on plant operability.

Health, Safety, and the Environment

- The Health, Safety and Environment Utilization Study was updated and a new working group on radiation protection was formed to aid in resolving industry-wide dosimetry issues.
- External dosimetry:
  - made improvements in the system used for performing x-ray irradiations
  - completed procedure for using the new gamma source system for inter-comparison studies
  - delivered hot-particle dosimetry systems to users and made available the French user manual
  - conducted an inter-comparison of whole-body dosimeters and type tests on extremity dosimeters
  - completed performance evaluation of super-heated drop detectors vs. track-etch detectors
- Internal Dosimetry: continued work on the evaluation of the dose from inhalation of tritium and carbon-14 containing organics and in the support of capability maintenance for the Biological Research Facility
- Radiation Monitoring:
  - continued study of potential internal contamination hazards that might be encountered during refurbishment or decommissioning .
  - pursuing development of a discriminating tritium monitor, performance testing of the Prescila neutron survey meter and development of a sensitive tritium alarming monitor
  - investigating the use of imaging systems to accurately identify radioactive surface contamination
- Environmental Impact and Biodiversity:
  - produced a generic model for upgrading environmental assessment documentation
  - COG guidance document on derived release limits was aligned with the draft CSA N288.1
  - validating atmospheric dispersion model in IMPACT
  - nearing completion of the testing of environmental tritium and carbon-14 models in the Environmental Modelling for Radiation Safety program is nearing completion.
- Occupational Radiation Protection:
  - Developing a field-tested prototype of the first of two intermediate level tritium suit ensembles
  - completed a report compiling methods to reduce worker exposure during feeder work
- Emissions management: gained improved understanding of the interaction of factors that might affect the toxicity of boiler blow-down
- Spills management: developed risk-based approach for detecting and quantifying the impact of offsite spill events that might occur at COG member facilities
- Waste management and pollution prevention: nearly completed review of practical and cost-effective methods for segregating clearance level waste at CANDU stations

Chemistry, Materials, and Components

- chemistry aspects of steam generator corrosion
- de-oxygenation of water systems and moderator cover gas systems
- reduction of radiation fields and dose
- non-destructive examination tools for steam generators and heat exchangers
- emergency core coolant strainer testing

- containment boundary degradation
- improved components, materials, maintenance and processes
- reactor vessel and piping material degradation
- steam generator and heat exchanger integrity and cleaning

Industry Standard Toolset

The Industry Standard Toolset program is a consolidation of the qualification, development and maintenance of different computer codes used for the design, safety analysis and operational support of CANDU reactors. This program is currently focused on 15 codes.

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. 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 and CANDU X programs.

AECL safety technology R&D is currently conducted in the following programs.

Fuel and Fuel Channel Behaviour

- analyzing severe accident progression to severe core damage states
- developing severe accident management measures
- completing of supporting core disassembly facility experiments and incorporation of resulting knowledge into current reactor designs and advanced CANDU concepts
- resolving fuel channel safety issues for deployment of an enhanced CANDU-6 reactor design
- developing a methodology for optimising fuel bundle thermal performance
- assessing safety technology support required for graphite disk fuel

Thermal Hydraulics

- assessing and resolving the issue of molten fuel moderator interaction
- providing void fraction, critical heat flux, pressure-drop, and post-dry out heat transfer data
- developing analytical and predictive methods (specifically addressing the effects of axial and radial power profiles in crept channels) for thermal hydraulics codes used for the analysis of advanced CANDU reactors
- improving the technology base for reactor safety experiments to address emerging issues (e.g., two-phase thermal hydraulics in headers and multi-channel geometries, high-temperature fuel-channel experiments)
- providing the technical basis for ensuring the reliability of passive safety systems for new CANDU designs

Fission Product and Containment Behaviour

- developing an integrated methodology for fission product release and transport that can be used to support EQ and dose assessments

Methodology Development

- developing a base capability in probabilistic safety assessment and best estimate methodologies, including uncertainty analysis
- addressing gaps in code validation identified during initial qualification of safety and licensing computer programs
- developing and applying a methodology for assessing the uncertainties associated with extrapolating from experimental results generated with scaled facilities
- supporting, developing and advancing safety analysis codes and safety analysis methodologies to address advanced CANDU product requirements
- developing a pilot framework for advancing the safety technology suite of computer codes to take advantage of developments in information technology, to improve maintainability, and to allow for functionality enhancements
- developing online monitoring options for key safety parameters

Appendix F: Generic Action Items

Safety issues are identified through research, new knowledge, hazard analysis, or accident mitigation strategies. A safety-related concern that cannot be resolved based on available knowledge is referred to as an outstanding safety issue.

CNSC staff has formally documented outstanding safety issues that are common to more than one station and that are complex in nature as Generic Action Items (GAIs). Further work, occasionally including experimental research, is required to more accurately determine the overall effect of a GAI on an NPP's safety. Nevertheless, CNSC staff judges that an NPP may continue to operate in spite of the existence of GAIs; because most GAIs deal with situations where safety margins still exist, but may be subject to potential degradation. Issues with confirmed, immediate safety significance are addressed by other means on a priority basis.

To ensure clear CNSC expectations for each GAI, CNSC staff has developed position statements that include closure criteria and an expected timeframe for closure. A GAI is used as a regulatory tool to define the scope of key safety issues, to identify outstanding technical issues and to specify requirements for resolution of the safety issue. GAIs are also used to monitor licensee progress on safety issues and to provide a basis for communication of this progress.

The GAI program has helped maintain regulatory focus on complex safety-related issues. Several GAIs require licensees to demonstrate a degree of certainty and conservatism in the safety analyses of design basis accidents. The GAI program has provided a vehicle for the CNSC to offer some degree of guidance on licensees' NPP safety research. Many GAIs have contributed to an improved understanding of safety issues, while others have led to changes to procedures, equipment and analysis at operating NPPs in Canada.

More detailed descriptions of "safety issues" and "closure criteria" relevant to GAIs are found in the second and third Canadian reports. This appendix focuses on brief descriptions of the safety issues and progress updates. As of January 1, 2004 to the end of the reporting period, there were 10 open GAIs; five had been closed since the third Canadian report, and one new GAI had been opened.

A. Continuing Generic Action Items

GAI 88G02: "Hydrogen Behaviour in CANDU Nuclear Generating Plants"

A loss of coolant accident (LOCA) can lead to substantial hydrogen releases to the containment compartment. The primary source for hydrogen generation is the radiolysis of the water in the primary heat transport system by radiation fields from intact fuel in the core. Radiolysis of water collected in the containment, due to radionuclides released from failed fuel, can also cause an appreciable amount of hydrogen to be released to the containment in the long term. In addition, in LOCA scenarios where emergency core coolant (ECC) is not initiated, oxidation of the over-heated fuel sheath is expected to result in considerable short-term releases of hydrogen into the containment. Significant long-term hydrogen releases can induce flammable and potentially explosive gas mixtures in entire containment compartments, while short-term releases can have a similar local impact in certain regions of the affected compartments.

Harsh radiological conditions, combustion loads, and potentially explosive loads from hydrogen ignition could challenge the integrity of containment and the systems, structures, and components needed during the post-accident phase.

A COG research and development program focuses on analyzing the scenarios and understanding the performance of a possible mitigating measure: passive autocatalytic re-combiners (PARs). A new industry team was established to ensure adequate PAR performance (for example, to resolve the issue of degradation in the self-start threshold) for making implementation decisions. As part of the ongoing evaluation, PAR units were installed for testing at Point Lepreau, Gentilly-2, Pickering A, and Bruce A. Based on test results to date, the industry may not need to investigate the option of enhancing PAR design. Outstanding analytical issues include the magnitude of the hydrogen source-term and the nature of short- and long-term mixing in containment. Work continues to reduce conservatism in the prediction of long-term hydrogen production by water radiolysis and to improve the analytical tools to calculate hydrogen behaviour in containment.

The CNSC is tracking resolution of these safety issues as part of the anticipated implementation of regulatory documents that define the safety requirements to be met by the containment system in design-basis accidents and beyond-design-basis accidents, and the safety analysis methodology to be used.

GAI 94G02: "Impact of Fuel Bundle Condition on Reactor Safety"

Certain fuel bundles irradiated in CANDU reactors have shown signs of more-than-expected degradation such as end plate cracking, spacer pad wear, element bowing, sheath wear, bearing pad wear, sheath strain, disappearance of the CANLUB layer, oxidation of defective fuel and fission product release.

Fuel bundle degradation depends on the reactor, fuel channel and fuel designs, fuel manufacture and operating conditions. The effects of bundle degradation on reactor safety are not fully known, partially because of the limitations of safety analysis methods. Because theoretical models have been unable to correlate these factors adequately to fuel conditions, fuel and pressure tube inspections are necessary. It is also necessary to conduct an integrated evaluation of information obtained from inspections and examinations, research and safety analyses. In the past, licensees did not have a formal process to ensure that the fuel and fuel channel conditions were identified and accounted for.

This GAI was closed for OPG in 2001 and for Bruce Power in 2002. In 2006, GAI 94G02 was also closed for NBPN based on the information describing the processes implemented at Point Lepreau and results of the CNSC evaluation of fuel performance. CNSC staff is reviewing a request for closure of this GAI for Hydro-Québec.

GAI 95G01: "Molten Fuel/Moderator Interaction"

A severe flow blockage in a fuel channel, or an inlet feeder stagnation break, could potentially lead to fuel melting, channel rupture and ejection of molten fuel into the moderator. Potentially, the resulting molten fuel/moderator interaction could damage the shut-off rod guide tubes and prevent shutdown system 1 from functioning properly. It could also damage other fuel channels or the calandria itself.

In 2000, licensees initiated an experimental program to study the nature of the interaction between molten fuel and the moderator. A panel of independent fuel-coolant interaction experts reviewed the experimental program and the industry's proposed resolution criteria. CNSC staff and industry accepted the panel's recommendations. CNSC staff also accepted the industry's proposed closure criteria and experimental program schedule.

The first of the planned four tests was carried out successfully in December 2004. By the end of 2006, one 5-kg and two 25-kg melt ejection tests had been performed. The industry is assessing the results from these tests to determine the need for further tests or modifications of the overall plan. The completion date for this GAI has been revised to June 2008.

GAI 95G02: "Pressure Tube Failure with Consequential Loss of Moderator"

The single and dual failure concept requires analyses of events caused by failures of process systems, along with analyses of initiating events coupled with the failure of one of the special safety systems. For the postulated scenario of a LOCA and a loss of ECC, the moderator system has been credited in the analysis as a heat sink. Heat transfer to the moderator is assumed to be via pressure tube (PT) contact with calandria tubes (CTs) following PT deformation due to heat-up. CNSC staff has accepted this mode of heat transfer because the moderator is considered to be independent of postulated initiating events and ECC failures.

For PT rupture, experiments have suggested that the moderator may not be available to cool the fuel channels. This is because a PT failure may lead to a CT failure and an end-fitting ejection, which would result in the draining of the moderator. In that case, the event involving a PT rupture and loss of ECC injection could result in severe damage to a large number of channels, with consequences in excess of those anticipated in the safety report.

In response to this GAI, the industry presented evaluation criteria for selection of feasible corrective actions (design and/or procedural changes), including a proposed cost-benefit methodology. More recently, the industry also submitted plans of action to reduce the risk associated with this postulated event and requested closure of this GAI. Bruce Power has already made a number of improvements at Bruce A and B to reduce the risk. CNSC staff has, in principle, agreed with the measures taken to mitigate the potential consequences of this event, and has also agreed that any substantial design changes to reduce the likelihood of the event could be implemented during plant refurbishment and fuel channel replacement.

As part of its refurbishment plan, NBPN considered replacing existing seam-welded CTs with more robust seamless CTs to address the concern identified in this GAI. However, design qualification tests revealed that the anticipated performance improvements of the seamless CT design would require redesigning the CT-to-tubesheet rolled-joint. NBPN presented arguments that engineering design changes would not be justified, based on a more detailed evaluation of the frequency of severe core damage due to a PT rupture. CNSC staff review of this issue is on-going. Other licensees have been requested to address the impact of this development for their facilities, but the industry is not pursuing the development of seamless CTs, and this has been communicated to the CNSC.

GAI 95G04: "Positive Void Reactivity Treatment in Large-Break LOCA Analysis"

Accuracy of void reactivity calculations is a significant safety issue in the analyses of design basis accidents involving channel voiding, especially for large LOCAs. In 1995, CNSC staff raised concerns about the adequacy of available evidence in support of best-estimate predictions of void reactivity, and subsequently requested all licensees to complete a suitable experimental program to improve related safety analyses, and to undertake adequate interim measures.

In 2001, a CANDU Owners Group (COG) report on void reactivity error assessment concluded that the new industry standard toolset (IST) reactor physics suite of computer codes over-predicts the void reactivity of CANDU fuel when compared to research reactor measurements. The report recommended fuel-type specific errors for void reactivity calculations by IST reactor physics codes for operating CANDU conditions at all fuel burn-ups. This recommended value of over-prediction of void reactivity has been credited in the recent large LOCA safety analyses with the new IST reactor physics suite of codes.

An independent panel has also discussed the acceptability of the uncertainty estimate in the IST reactor physics codes' prediction of void reactivity for operating CANDU conditions. The industry dispositioned the recommendations in the panel's report in 2003 and proposed further research and development activities. The majority of the proposed activities were completed and all licensees requested the closure of this GAI in 2004. CNSC staff review is ongoing.

GAI 95G05: "Moderator Temperature Predictions"

In some large LOCA analyses, the integrity of fuel channels depends on the capability of the moderator to act as the ultimate heat sink. As fuel channels heat up, PTs balloon diametrally and contact the CTs. Fuel channels remain intact upon contact if the moderator fluid outside the CTs is cold enough to provide good heat removal. However, channels may fail if the moderator temperature is too high to prevent the outside of the CTs from drying out following contact on the inside with the pressure tubes.

CNSC staff requested validation of the computer code used to calculate the moderator temperature distribution against 3-D experimental data that was representative of reactor conditions. An integral 3-D test was completed in 2001 to the satisfaction of CNSC staff, and the validation of the computer code MODTURC-CLAS was performed against both separate effect testing and the results of the 3-D integral test. The industry team submitted the code validation to CNSC in December 2005 with a request to close this GAI.

CNSC staff's review of the large submission started in 2006 and is scheduled to continue to the end of 2007.

GAI 99G01: "Quality Assurance of Safety Analysis"

The acceptability of the safety-related information established by safety analyses depends on the degree of conservatism in the analyses and the credibility of the computer codes, methods and input information. Licensees need to perform safety analyses in a systematic manner, using QA principles, to ensure confidence in the licensing basis and safe operating envelope for each facility.

CNSC staff had become aware, through audits and assessments, of an increasing number of occurrences of poor safety analysis practices by power reactor licensees caused by inadequate QA. The initiation of this GAI in 1999 was due to the CNSC staff conclusion that inadequate QA of safety analyses had caused a reduction in the overall confidence in the safety analysis results.

The industry responded by establishing QA frameworks and procedures related to safety analysis, and by taking actions to satisfy all relevant closure criteria. CNSC staff closed this GAI for Bruce Power in 2003 and for OPG in 2006. The results of the audit at NBPN were satisfactory, but closure of this GAI is contingent on the compatibility of the newly established procedures with the overall QA program being developed at NBPN. A relevant audit was carried out for Hydro-Québec in 2005 with satisfactory results, and closure of this GAI is expected in the near future.

GAI 99G02: "Replacement of Reactor Physics Computer Codes Used in Safety Analysis of CANDU Reactors"

Licensees use reactor physics methods and computer codes to support nuclear design, operation and compliance with the safe operating envelope. There are stringent requirements on accuracy and validation of these methods and codes due to their role in the confirmation of safe operation. Recent experimental data, as well as reviews of key computer codes, identified several shortcomings. These deficiencies are related to inaccurate predictions of key parameters for accident conditions, lack of proper validation and a significant lag of licensees' methods and codes behind the current state of knowledge. These shortcomings had a negative effect on the overall confidence in the results of reactor physics analyses, especially for those analyses where safety margins are small.

Under this GAI, licensees are required to carry out a structured program of replacement of reactor physics computer codes. A report of an independent expert panel (see GAI 95G04) assessed the adequacy of estimated uncertainties of certain key parameters predicted by the codes. Two licensees (Bruce Power and OPG) completed an agreed set of activities, declared the new reactor physics toolset in service for future accident analysis, and completed a second set of activities on code validation. The new reactor physics toolset was applied in licensing safety analysis and commissioning of the Bruce A Units 3 and 4 restart. In 2004, Bruce Power and OPG requested the closure of this GAI. The completion of the CNSC's review of the request is planned for 2007.

HQ and NBPN are implementing fuel management software prior to requesting closure of the GAI. COG Reactor Physics Working Group routinely reviews the results of these activities .

GAI 00G01: "Channel Voiding During a Large-Break LOCA"

CNSC staff has a concern that the computer codes used for prediction of overpower transients for CANDU reactors with a positive coolant void reactivity coefficient have not been adequately validated. This GAI requires the licensees to carry out direct void fraction measurements, provide an assessment of the scaling of the results to the phenomena expected in the reactor, perform validation exercises using these data and complete an impact assessment on the safety margins.

Void fraction measurements in AECL's RD-14M facility have been completed, and data analysis reports have been submitted to the CNSC. The industry has provided information on the computer code validation exercises and the scaling assessment.

After reviewing the information submitted by the industry, CNSC staff requested each licensee to provide a plan to:

- document the scaling rationale for the RD-14M simulated large LOCA experiments and demonstrate the relevance of the channel void measurements in these RD-14M experiments to the reactor situation;
- estimate the simulation uncertainty of the system thermal-hydraulic code for predicting the channel void fraction during the rapid voiding phase following a large LOCA using the simulation and experimental results on the channel voiding behaviour in the RD-14M simulated large LOCA tests;
- confirm that the system thermal-hydraulic code, when simulating the channel voiding behaviour in a large LOCA, is used in the same way as in the validation exercises (any deviations in the usage of the computer code in safety analysis are to be identified, explained and justified); and
- perform sensitivity calculations to examine the effect of uncertainty in the channel void predictions from the system thermal-hydraulic code during the early blow-down phase on key safety parameters (for example, peak fuel centreline and sheath temperatures) of a large LOCA).

In 2006, the industry submitted a scaling assessment of RD-14M large LOCA tests for the channel voiding behaviour during the power pulse phase. This assessment is under review by CNSC staff.

GAI 01G01: "Fuel Management and Surveillance Software Upgrade"

This GAI applies only to Bruce Power and OPG.

Compliance with reactor physics safety limits that define the safe operating envelope, such as channel and bundle power limits, is based on analyses performed with a fuel management computer code. Recent, more rigorous scrutiny of the accuracy of methods, acceptance criteria, assumptions and results of safety analyses of various design basis accidents led to significant restrictions of operating parameters, including channel and bundle powers, as well as the introduction of additional physics parameters for compliance purposes, such as fuel string relocation reactivity and minimum margin to axial constraint. The significance of compliance with safety-related reactor physics limits has therefore increased. This has enhanced the need for an improved analytical model validated over a broader range of applications and conditions as well as better-defined compliance allowances and more consistent procedures.

To achieve closure of this GAI, licensees were required to implement a structured program for reactor core surveillance that covers fuel management software upgrade and validation as well as validation and qualification of the compliance methodology.

Work at Bruce Power and OPG included modeling improvements to the SORO computer code and estimation of error allowances.

A significant milestone was achieved in December 2003 with the implementation of the first improved version of the computer code WIMS-IST-SORO. Significant progress was made with the completion of work related to validation against flux measurements in a CANDU-6 reactor. The completion of CNSC staff's review of the request is planned for 2007.

B. New Generic Action Items (Since the third Canadian Report):

GAI 06G01: "Emergency Core Coolant Strainer Deposits"

Preliminary research findings of the Integrated Chemical Effects Test (ICET) program in the United States have raised concerns about the formation of deposits on ECC system strainers. To address this concern for CANDU reactors, this GAI was created in 2006.

A postulated LOCA would dislodge significant quantities of insulation material, both fibrous and particulate. Much of this debris is expected to be transported to the reactor building sump with the coolant lost from the reactor through the break. ECC recirculation recovers water from the sump, cools it and returns it to the reactor to cool the core. The ECC strainers are located in the sump and protect the ECC recirculation flow path by preventing the debris from entering the ECC system. As a result, a layer builds up over the strainer surface. The strainers are designed with sufficient surface area to prevent the debris bed from impeding flow.

The ICET program examines the impact of reactor building sump chemistry following a LOCA and possible implications for ECC strainers during recirculation following a LOCA. In some of the ICET tests, a gelatinous deposit was discovered on the fibre samples in the tank. There is a concern that such chemical deposits could lead to a partial blockage of the strainer thereby impairing the ECC recirculation.

Licensees have submitted information giving confidence that the chemical environment in CANDU reactors does not include the features that led to possibly harmful deposits in the ICET tests. In particular, the study showed that addition of tri-sodium phosphate (TSP) to the water in the ICET tests led to accelerated aluminium corrosion and the formation of the deposits. CANDU reactors do not make use of TSP to raise sump pH after a LOCA. CNSC staff accepted the conclusions of this study.

However, licensees could not completely exclude chemical effects under CANDU sump conditions. Therefore an experimental program was quickly established to close this gap in knowledge. The program is on schedule for completion in 2007.

C. Generic Action Items Closed (Since the third Canadian Report)

As of January 1, 2004 to the end of the reporting period, five industry-wide GAIs were closed. For a list of previously closed GAIs, please refer to the second and third Canadian reports.

GAI 90G02: "Core Cooling in the Absence of Forced Flow"

Failure of the primary heat transport pumps to provide forced circulation of water for fuel cooling is a possibility in some accident sequences. The reactors then rely on natural circulation of the coolant to remove residual heat from the fuel to the steam generators. Natural circulation experiments at AECL Whiteshell Laboratories showed degraded cooling in some channels if coolant inventory is low. The experimental results cast doubt on the safety analysis predictions regarding the effectiveness of natural circulation under partial inventory conditions. Licensees were requested to identify the causes leading to the observed degraded cooling conditions and, if needed, to revise their safety analyses or implement design changes. Prior to 2004, this GAI was closed for all licensees except NBPN. In 2004, CNSC staff completed the evaluation of the analysis submitted by NBPN and concluded that the closure criteria were met. The GAI was closed for NBPN in 2004.

GAI 91G01: "Post-Accident Filter Effectiveness"

In certain postulated accidents, venting of containment may be needed to reduce the risk of an uncontrolled release of radioactive material. Licensees have been required to demonstrate that the filters are capable of performing their design function and that adequate testing and maintenance activities for them are in place. The filters covered by this GAI are the containment emergency filtered air discharge system (EFADS) filters and other non-EFADS filters that are credited in safety analyses.

The GAI was previously closed for Hydro-Québec. By the beginning of 2004, OPG and Bruce Power had provided additional information to meet the closure criteria for non-EFADS filters at Pickering A and B, Darlington, and Bruce B (having already addressed EFADS). The review of this information concluded that the closure criteria for this GAI for all OPG and Bruce Power stations were met. Also, the review resulted in a number of actions that OPG and Bruce Power committed to complete. The GAI was closed for Pickering A and B, Darlington, and Bruce A and B in 2004.

In 2006, CNSC staff closed this GAI for NBPN based on a number of activities, including the development of an additional post-accident venting procedure as well as detailed analyses to demonstrate that hydrogen burns within the filtering systems are precluded.

GAI 94G01: "Best Effort Analysis of ECCS Effectiveness"

The third Canadian report stated that this GAI was superseded by GAI 98G02. It was only applicable to Bruce Power and OPG, and the GAI was formally closed for them in January 2004.

GAI 98G01: "Heat Transfer Pump Operation under Two-Phase Flow Conditions"

The operation of the primary heat transfer system (HTS) pumps under LOCA conditions can damage the integrity of the system piping due to the generation of large pressure pulsations and excessive pump vibration. In the past, piping analysis was performed using limited experimental information from laboratory tests. This approach was sensitive to the interpretation of the test data and their application to the reactor. Reassessment was needed to obtain a more realistic representation of the behaviour of the pump and piping under various accident conditions. In particular, the fatigue analysis of the HTS piping required updating with the use of a conservative forcing function.

This GAI had been previously closed for all stations except Bruce A.

In 2005, Bruce Power provided additional analysis as requested by CNSC staff and requested closure of the GAI. The Bruce Power submission recommended reducing the time of automatic pump trip to 10 minutes.

CNSC staff agreed with the Bruce Power position that the recommended action would ensure piping integrity under the most severe conditions resulting from two-phase operation of HTS pumps. CNSC staff also verified that the reduction in pump trip time did not compromise fuel cooling. On this basis, CNSC staff closed the GAI.

GAI 98G02: "Validation of Computer Programs Used in Safety Analysis of Power Reactors"

In the past, CNSC staff assessed licensees' computer programs and safety analysis methods and identified several inadequate practices with respect to computer program validation. Examples of poor practices included lack of a managed process in performing validation, poor documentation of computer program validation, poor applicability of validation due to the limited range of conditions in the validation experiments in comparison with the reactor analysis, and inadequate assessment of the impact of dimensional scaling and important phenomena for which adequate validation data did not exist. CNSC staff concluded that these inadequate practices eroded overall confidence in the safety analysis results.

The industry has responded favourably to this GAI by establishing a quality control process to improve the computer code validation and by achieving an overall level of baseline validation for a specific set of major computer codes used in safety analyses. These efforts, once confirmed by CNSC staff's reviews and audits of relevant licensees' programs, were considered to be sufficient to warrant closing this GAI. The Industry Standard Toolset Program will undertake the ongoing maintenance and configuration management of the major safety analysis codes. This GAI was closed for Bruce Power and OPG in 2003. It was closed for NBPN in 2005 following its demonstration that the safety analysis QA was compatible with the overall QA program under development at Point Lepreau. Based on the satisfactory results of CNSC staff evaluation at Gentilly-2, this GAI was closed for Hydro-Québec in 2006.

Appendix G: Description and Results of CNSC's Assessment and Rating System for Nuclear Power Plants

The CNSC uses five rating categories to assess licensee programs and their implementation in nine designated safety areas. The definitions of the rating categories (see CMD 02-M5) are contained in Table G.1. The safety areas, associated programs and review factors used in the assessment are described in Table G.2. Two of the safety areas, "Site Security" and "Safeguards", are omitted from Table G.2 because they are outside the scope of this report. While the rating categories and the review factors of these two tables focus mainly on the CNSC regulatory requirements, CNSC performance expectations provide guidance and add completeness to the review process (always taking into account that licensees are free to propose alternate means of meeting these expectations).

A summary of the ratings of all Canadian NPPs for the years 2003 through 2006 is given in Table G.3. This table includes ratings for each of the relevant safety areas with respect to licensee programs and their implementation.

Table G.1: List and Definitions of CNSC Rating Categories

A - Exceeds requirements
Assessment topics or programs meet and consistently exceed applicable CNSC requirements and performance expectations. Performance is stable or improving. Any problems or issues that arise are promptly addressed, such that they do not pose an unreasonable risk to the maintenance of health, safety, security, environmental protection, or conformance with international obligations to which Canada has agreed.

B - Meets requirements
Assessment topics or programs meet the intent or objectives of CNSC requirements and performance expectations. There is only minor deviation from requirements or the expectations for the design and/or execution of the programs, but these deviations do not represent an unreasonable risk to the maintenance of health, safety, security, environmental protection, or conformance with international obligations to which Canada has agreed. That is, there is some slippage with respect to the requirements and expectations for program design and execution. However, those issues are considered to pose a low risk to the achievement of regulatory performance requirements and expectations of the CNSC.

C - Below requirements
Performance deteriorates and falls below expectations, or assessment topics or programs deviate from the intent or objectives of CNSC requirements, to the extent that there is a moderate risk that the programs will ultimately fail to achieve expectations for the maintenance of health, safety, security, environmental protection, or conformance with international obligations to which Canada has agreed. Although the risk of failing to meet regulatory requirements in the short term remains low, improvements in performance or programs are required to address identified weaknesses. The licensee or applicant has taken, or is taking appropriate action.

D - Significantly below requirements
Assessment topics or programs are significantly below requirements, or there is evidence of continued poor performance, to the extent that whole programs are undermined. This area is compromised. Without corrective action, there is a high probability that the deficiencies will lead to an unreasonable risk to the maintenance of health, safety, security, environmental protection, or conformance with international obligations to which Canada has agreed. Issues are not being addressed effectively by the licensee or applicant. The licensee or applicant has neither taken appropriate compensating measures nor provided an alternative plan of action.

E - Unacceptable
Evidence of either an absence, total inadequacy, breakdown, or loss of control of an assessment topic or a program. There is a very high probability of an unreasonable risk to the maintenance of health, safety, security, environmental protection, or conformance with international obligations to which Canada has agreed. An appropriate regulatory response, such as an order or restrictive licensing action has been or is being implemented to rectify the situation.

Table G.2: CNSC Safety Areas, Programs and Review Factors used in Rating Canadian NPP Performance

Safety Area	Programs	Review Factors
1. Operating Performance	1. Organization and Plant Management	• global program integration • financial guarantees • review of station transients • overall plant status and material condition • reporting requirements (self-assessment and records) • public information program
	2. Operations	• field inspections • control room inspections • procedural adherence • communications • change control (approvals process, configuration management) • outage management • plant walk-downs (fire protection, environmental qualification, emergency preparedness, configuration management, emergency core cooling flow path, seismic, etc.) • operator certifications (internal certification process, records)
	3. Occupational Health and Safety (Non-radiological)	• industrial health and safety standards • hazardous materials management • worker health and safety committees • work planning ,work practices and protection, reporting and records other government programs or requirements
2. Performance Assurance	1. Quality Management	• program definition (quality management manual, policies, procedures) • identification and resolution of problems • management self-assessments • work planning, change control, documentation control, control of items processes and practices, records • use of operating experience (OPEX) • organization design, departmental roles and responsibilities, communication, accountability
	2. Human Factors	• human system interface • fitness for duty • work environment • staffing (process, levels) • procedures and job aids, maintenance of procedures • organizational factors including safety culture
	3. Training	• personnel qualifications, capabilities • training processes and procedures • certified staff training (examination/standards/procedures) • non-certified staff training • facilities and support services (simulator/aids/classroom)
3. Design and Analysis	1. Safety Analysis	• safety report update • licensing basis (assumptions)

Safety Area	Programs	Review Factors
		• safe operating envelope (operating policies and principles) • methodology and model verification and validation • ageing (impact on safety analysis)
	2. Safety Issues	• research and incorporation of new knowledge • action item placement and management (generic, site specific) • hazard analyses (internal, external, fire hazard assessment) • accident mitigation and management
	3. Design	• description of plant design (documentation of design basis, system classification, configuration management) • fire protection • design change projects (safety enhancements, links to events, corrective actions, OPEX, human factors)
4. Equipment Fitness for Service	1. Maintenance	• work control and conduct of maintenance (permits and procedures) • procedural adherence (procedures and job aids) • planning (maintenance activities and backlog reduction, corrective maintenance, preventive maintenance) • surveillance and inspection • plant life management (ageing/obsolescence) • facilities, equipment and materials • stores and warehouses • configuration management
	2. Structural Integrity	• pressure retaining components • in service inspection • fitness for service programs
	3. Reliability	• probabilistic safety assessment, models and methodology • system unavailability performance
	4. Equipment Qualification	• environmental • seismic • fire protection • quality level • electronic/magnetic interference • chemistry control
5. Emergency Preparedness	1. Emergency Preparedness	• emergency response • consolidated emergency plan (fire response and mitigation considerations, security, other events) • emergency response training exercises • emergency response facilities and procedures

Safety Area	Programs	Review Topics
6. Environmental Protection	1. Environmental management systems	• environmental protection systems • emissions reduction • pollution prevention
7. Radiation Protection	1. Personnel exposure	• radiation exposure control (ALARA, dose control during outages) • action levels • contamination control

Note: Two additional CNSC safety areas, "Site Security" and Safeguards", have been omitted from the table.

Table G.3: Summary of Report Cards for Canadian Licensees for the years 2003, 2004, 2005 and 2006

		Bruce A				**Bruce B**				**Darlington**				**Pickering A**				**Pickering B**				**Gentilly-2**				**Point Lepreau**			
	Year	‘03	‘04	‘05	‘06	‘03	‘04	‘05	‘06	‘03	‘04	‘05	‘06	‘03	‘04	‘05	‘06	‘03	‘04	‘05	‘06	‘03	‘04	‘05	‘06	‘03	‘04	‘05	‘06
Safety Area																													
Operating	**P***	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
Performance	**I****	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	B	B	B	B	B	B	B	B	B	B	B
Performance	**P**	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	B	B	C	B	B	B
Assurance	**I**	B	B	C	B	B	B	B	B	C	B	B	B	C	B	B	B	B	B	B	B	C	C	C	B	C	B	B	B
Design &	**P**	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	B	B	B	B	B	B	B	B	B	B	B
Analysis	**I**	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	B	C	B	B	B	B	B	B	B	B	B
Equipment	**P**	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
Fitness for Service	**I**	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	B	B	B	B	B	B	C	B	B
Emergency	**P**	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Preparedness	**I**	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	B	B	B	C	C	B	B
Environmental	**P**	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
Protection	**I**	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
Radiation	**P**	B	B	B	B	B	B	B	B	A	B	B	B	B	B	B	B	B	B	B	B	A	B	B	B	B	B	B	B
Protection	**I**	B	B	B	B	B	B	B	B	B	B	B	A	B	B	B	B	B	B	B	B	C	B	B	B	B	C	B	B

Legend

A = Exceeds requirements B = Meets requirements C = Below requirements D = Significantly below requirements E = Unacceptable

*	P	Program
**	I	Implementation

Note:

The grades for the CNSC safety areas “Site Security” and Safeguards” have been omitted from the table.

ANNEXES

Annex 7.2 (i): CNSC Regulatory Documents

The information in this annex reflects the status of the CNSC regulatory document program at the end of the reporting period. The future direction of the program and its anticipated impact on the types and numbers of documents that will be produced in future reporting periods is described in Article 7, section 7.2 (i).

The CNSC currently issues (as of the end of the reporting period) the following four types of regulatory documents:

- Regulatory Policy (P): A regulatory policy describes the philosophy, principles or fundamental factors on which the regulatory activities associated with a particular topic or area of concern are based. It describes why a regulatory activity is warranted, and therefore promotes consistency in the interpretation of regulatory requirements.
- Regulatory Standard (S): A regulatory standard clarifies the CNSC's expectations of what the licensee should do, and it becomes a legal requirement when it is referenced in a licence or other legally enforceable instrument. A regulatory standard provides detailed explanation of the outcomes the CNSC expects the licensee to achieve.
- Regulatory Guide (G): A regulatory guide informs licensees about how they can meet CNSC expectations and requirements. It provides licensees with a recommended approach for meeting particular aspects of the requirements and expectations associated with their respective licensed activities.
- Regulatory Notice (N): A regulatory notice informs licensees and other stakeholders about significant matters that warrant timely action.

The regulatory document process includes two sub-processes: the document identification process and the document development process. The document identification process begins with a call for regulatory document proposals and ends with a group of approved regulatory document proposals. The document development process involves the development of the regulatory document, from work plan to published regulatory document. External stakeholders have the opportunity to comment on the list of proposed documents during the document identification process and on the content of the individual documents during the development process.

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

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

Additional information on the CNSC's regulatory documents program is available on the CNSC Web site at http://www.nuclearsafety.gc.ca.

Table A 7.2(i) a lists some key published documents available from the CNSC as hard copies or in PDF format.

Table A 7.2(i) a – Current Regulatory Policies, Standards and Guides	
Document Number[1]	**Document Title and Year of Publication**
P-119	*Policy on Human Factors* (2000)
P-211	*Compliance* (2001)
P-223	*Protection of the Environment* (2001)
P-242	*Considering Cost-benefit Information* (2000)
P-290	*Managing Radioactive Waste* (2004)
P-299	*Regulatory Fundamentals* (2005)
P-325	*Nuclear Emergency Management* (2006)
R-7	*Requirements for Containment Systems for CANDU Nuclear Power Stations* (1991)
R-8	*Requirements for Shutdown Systems for CANDU Nuclear Power Stations* (1991)
R-9	*Requirements for Emergency Core Cooling Systems for CANDU Power Plants* (1991)
R-117	*Requirements for Gamma Radiation Survey Meter Calibration* (1995)
S-98 rev1	*Reliability Programs for Nuclear Power Plants* (2005)
S-99	*Reporting Requirements for Operating Nuclear Power Plants* (2003)
S-106 rev 1	*Technical and Quality Assurance Requirements for Dosimetry Services* (2006)
S-210	*Maintenance Programs for Nuclear Power Plants* (2007)
S-294	*Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* (2005)
S-296	*Environmental Protection Policies, Programs and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills* (2006)
R-10	*The Use of Two Shutdown Systems in Reactors* (1977)
R-77	*Overpressure Protection Requirements for Primary Heat Transport Systems in CANDU Power Reactors Fitted with Two Shutdown Systems* (1987)
R-100	*The Determination of Effective Doses from the Intake of Tritiated Water* (1987)
G-91	*Ascertaining and Recording Radiation Doses to Individuals* (2003)
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-147	*Radiobioassay Protocols for Responding to Abnormal Intakes of Radionuclides* (2003)
G-149	*Computer Programs Used in Design and Safety Analyses of Nuclear Power Plants and Research Reactors* (2000)
G-206	*Financial Guarantees for the Decommissioning of Licensed Activities* (2000)
G-219	*Decommissioning Planning for Licensed Activities* (2000)
G-225	*Emergency Planning at Class I Nuclear Facilities and Uranium Mines and Mills* (2001)
G-228	*Developing and Using Action Levels* (2001)
G-276	*Human Factors Engineering Program Plans* (2003)
G-278	*Human Factors Verification and Validation Plans* (2003)
G-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)

[1] Prior to 2003, all CNSC (and AECB) regulatory documents were prefixed by an "R", indicating "regulatory", regardless of whether they were regulatory policies, standards, guides or notices. Draft regulatory documents contained the prefix "C" for "consultative". In early 2003, a new naming convention was adopted. Regulatory policies, standards, guides and notices are now designated by a "P", "S", "G" or "N" respectively, before the document number. Draft documents are indicated by the word "draft" in the title and in the headers on each page.

The draft regulatory documents listed in Table A 7.2(i) b are also available through the CNSC Web site at the time of writing this report. These documents have been issued for external stakeholder comment and the comment periods are now closed. CNSC staff has not yet revised, reissued for further comment, withdrawn or formalized the documents.

Table A 7.2(i) b – Draft Regulatory Standards and Guides	
Document Number	**Document Title**
C-006	*Requirements for the Safety Analysis of CANDU Nuclear Power Plants*
S-204	*Certification of Persons Working at Nuclear Power Plants*
S-224	*Environmental Monitoring Program at Class I Nuclear Facilities and Uranium Mines and Mills*
S-310	*Safety Analysis for Nuclear Power Plants*
G-224	*Environmental Monitoring Program at Class I Nuclear Facilities and Uranium Mines and Mills*
G-353	*Guidelines for Testing Emergency Measures*
G-360	*Life Extension of Nuclear Power Plants*

Use of IAEA Documents in CNSC Regulatory Documents

IAEA standards continue to serve as references and benchmarks for the Canadian nuclear safety documents, as they have for many years. Table A 7.2(i) c identifies some published and draft CNSC regulatory documents that were developed using IAEA standards.

Table A 7.2 (i) c	
Published CNSC Regulatory Document	**Associated IAEA Standard**
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
Draft CNSC Regulatory Document	
S-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
G-360, *Life Extension of Nuclear Power Plants*	1. Safety Standards Series. NS-G-2.10

Annex 7.2 (iii) c: Details Related to Verification of Compliance

Specific Areas of Verification Activities (in addition to Appendix C)

• Fuel handling • Startup • Shutdown safety • Heat sinks • Outage management • Fuel and physics • Pressure boundary • Effluent control and monitoring • Environmental monitoring	• Control room • Reactor building • Turbine hall • Battery room • Control equipment room • Containment • Emergency coolant injection • Shutdown System 1 • Shutdown System 2 • Stand-by safety systems • Safety-related systems • Electrical systems

Reports Required by CNSC Regulatory Standard 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	reaching of action levels	operations
safety-significant non-compliances with licensing documents	performance and status of certified personnel	performance indicators
deficiencies in records	problems identified by research or analysis	facility description and safety analysis updates
events or incidents with significant implications for health and safety		environmental monitoring
releases		research and development progress
process failures		periodic inspections
actuations, spurious operations, and degradations of safety systems		degradation of pressure boundaries
degradations, excessive load conditions (observed or calculated), failures, configuration contraventions of pressure boundaries		reliability
reductions in effectiveness of reactor and turbine control systems		fuel monitoring and inspection
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		

Performance Indicators

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 operating licence references to CNSC regulatory standard S-99.

These performance indicators are to be used in conjunction with other information gathered by the CNSC. The overall regulatory safety assessment process includes the conclusions drawn from the performance indicators, from event analysis and from compliance verification activities. Conclusions drawn from these three elements, taken alone or in combination, may result in additional regulatory inspections. The CNSC performance indicators are as follows:

- Accident Severity Rate, Accident Frequency;
- Chemistry Index;
- Chemistry Compliance Index;
- Change Control Index;
- Radiological Emergencies Performance Index
- Emergency Response Organization (ERO) Drill Participation Index;
- Emergency Response Resources Completion Index;
- Non-Compliance Index;
- Number of Pressure Boundary Degradations;
- Preventive Maintenance Completion Ratio;
- Radiation Occurrence Index;
- NPP Radiation Dose;
- Number of Missed Mandatory Safety System Tests;
- Number of Unplanned Transients; and
- Unplanned Capability Loss Factor.

Some of the indicators can be used to measure the station performance as a whole, while some are more suited to measure performance in specific programs. Specification sheets that provide, among other things, the purpose and calculation method for the indicator, and data sheets have been developed to ensure standardized reporting. Definitions of the performance indicators and the data sheets are included in S-99.

These performance indicators have predictive or reactive attributes, or both. Predictive indicators measure trends and allow inferences to be made about any likely future deterioration in performance. They can therefore help identify potential problems so corrective or preventive measures can be taken. Reactive indicators prompt immediate action to correct deficiencies and prevent further deterioration.

Annex 10 a: Safety Policies at the Nuclear Power Plants

As stated in Article 10, each NPP operator in Canada has established, as part of their management system, an over-riding priority to safety.

Each operating organization has chosen a different style of demonstrating its priority to safety, with some organizations choosing to state their high level safety principles as part of a distinct nuclear safety policy for their organization.

For example, the following is an excerpt from the OPG nuclear safety policy:

> *Ontario Power Generation (OPG) is committed to provide all prudent and necessary resources required to operate nuclear stations in a safe, reliable manner, secure nuclear sites, safeguard nuclear materials, safeguard health and safety of workers, public and environment from radiological hazards, and prevent and mitigate the consequences of accidents, in compliance with applicable laws. The Board of Directors shall review nuclear safety performance on a regular basis.*
>
> *OPG shall govern its operations and performance to ensure that the risks associated with nuclear operations and activities are maintained at reasonable levels and that sound nuclear safety and defence in depth practices are in place and sustained. OPG shall work to establish and maintain a positive "safety culture" that demonstrates a set of principles, attitudes and observable behaviours that ensure nuclear plant safety is the overriding priority among all staff within the business.*

The responsibilities of the Chief Executive Officer and Chief Nuclear Officer are formally defined to include ones specifically related to safety.

Similarly the Bruce Power nuclear safety policy states:

> *Consistent with its value of Safety First, Bruce Power shall ensure that Nuclear Safety is always considered the overriding priority in its business decisions and activities. In this regard, it must carry out all activities with solemn acceptance of the responsibility we have to the public, each other, and the environment, as a consequence of our use of nuclear technology. As the operator of a nuclear plant, Bruce Power accepts that its fundamental nuclear safety objective is to protect the public, site personnel and the environment from harm, by establishing and maintaining effective defences against radiological hazards.*

The Bruce Power nuclear safety policy provides additional elaboration related to the protection of safety margins, maintenance of defence-in-depth, and safety analysis.

At Gentilly-2, the Hydro-Québec policy on nuclear safety has a similar statement of high-level values and goals, as illustrated in the following passage:

> *The Thermal and Nuclear Generation Division seeks to become a reference point in nuclear safety, as much through the commitment of all its staff to a strong safety culture than through the quality of its relationship with the CNSC. The management commits to:*
>
> - *giving safety the highest priority;*
> - *abiding rigorously by the current regulations and fulfilling its commitments to the regulatory bodies;*

- *seeking excellence in all activities with potential consequences on safety;*
- *clarifying and increasing the standing of the nuclear safety related roles and responsibilities of everyone.*

The policy also lists important supporting principles relating to such things as team work, continuous improvement, honesty and transparency.

The *Nuclear Management Manual*, the highest-level document governing NBPN's operations of Point Lepreau, has as the first point of the management commitment:

> *NB Power Nuclear is committed to the safe, reliable and efficient operation of PLGS.*

The organization's mission is stated as follows:

> *To operate the Point Lepreau Generating Station to provide electricity safely, ….*

The first of the core values of the organization is stated as:

> *Safety First* -- *We recognize and take seriously the unique safety requirements of the nuclear core. We are committed to employee and public safety.*

In addition, the management system is introduced by the following statement:

> *Our management System is a combination of the culture and interrelated activities that are used to direct and carry out work. It includes the management and support of personnel to enable them to implement the documented processes established within the Management System so that the performance objectives are achieved safely, consistently and efficiently.*

Employee responsibilities are stated in the management system and are also stated in the Station Instruction on Operations Expectations and Practices.

Annex 11.2 a: Requirements for Qualification and Numbers of Workers

A hierarchy of laws and regulations specify the requirements for personnel who perform critical safety-related activities. These documents address the required number of staff as well as their qualifications and training.

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

Paragraphs 21(1) (i) and 44 (1) (k) of the *Nuclear Safety and Control Act* provide the legislative basis for the certification, qualification, training and examination of personnel. Paragraphs 12 (1) (a) and (b) of the *General Nuclear Safety and Control Regulations* specify that the licensee shall:

- ensure the presence of a sufficient number of qualified workers to carry on the licensed activity safely and in accordance with the Act, the regulations made under the Act and the licence; and
- train the workers to carry on the licensed activity in accordance with the Act, the regulations made under the Act and the licence.

The *Class I Nuclear Facilities Regulations* require each applicant for a licence to provide details about the qualifications, training and experience of any worker involved in the operation or maintenance of the NPP. Requirements are in place for the application for a licence to construct (subsection 5(l)), the licence to operate (subsections 6 (m) and 6 (n)), and the licence to decommission (subsection 7 (j)).

The following requirements are included in NPP operating licences related to numbers of personnel, qualifications, and training.

- Enough qualified personnel (minimum shift complement) must be in attendance at all times to make sure there is safe operation of the NPP. This includes ensuring a sufficient number of qualified personnel to complete all necessary actions to bring the reactor to a safe state. The minimum complement is specified in administrative documents that require CNSC approval for change.
- A sufficient number of the following certified positions must be in attendance at all times at an NPP, except as otherwise approved in writing by the CNSC. These will vary depending upon the design of the NPP:
    - authorized nuclear operator/control room operator;
    - 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.
- Significant changes to staffing and organization documents referenced in the licence must be approved by the CNSC before implementation.

Each licensee has practices that address these personnel issues.

Annex 13 a: Definition of Safety-related Systems

The requirements of the CSA-N286 series of QA standards apply to safety-related systems, which are defined as those systems, and the components and structures thereof, which, by virtue of failure to perform in accordance with the design intent, have the potential to impact on the radiological safety of the public or plant personnel from the operation of the NPP. Those systems, and the components and structures thereof, are associated with the following:

(a) the regulation (including controlled startup and shutdown) and cooling of the reactor core under normal conditions (including all normal operating and shutdown conditions);
(b) the regulation, shutdown, and cooling of the reactor core under anticipated operational occurrences and accident conditions, and the maintenance of the reactor core in a safe shutdown state for an extended period following such conditions; and
(c) limiting the release of radioactive material and the exposure of plant personnel and/or the public to meet the criteria established by the licensing authority with respect to radiation exposure during and following normal conditions, anticipated operational occurrences, and accident conditions.

The term “safety-related system” covers a broad range of systems, from those having very important safety functions to those with a less direct effect on safety. The larger the potential radiological safety effect due to system failure, the stronger the “safety-related” connotation. The term “safety-related” also applies to certain activities associated with the design, manufacture, construction, commissioning, and operation of safety-related systems and to other activities which could similarly affect the radiological safety of the public or plant personnel. Such activities include environmental and effluent monitoring, radiation protection and dosimetry, and radioactive material handling (including waste management). The larger the potential radiological safety effect associated with the performance of the activity, the stronger the “safety-related” connotation.

Annex 14 (i) a: Content of the Safety Report

The typical safety report is organized into three parts, each of which deals with a separate aspect of the nuclear power plant (NPP).

i) Part 1 contains an introduction to the safety report, a general description of the NPP, and a detailed description of the site. Typically, the site description in Part 1 includes the following characteristics:

- general description of the site
- geography of the site and land use for recreation and commerce as well as information such as population distribution
- meteorology of the site
- hydrology of the site
- geology and seismology of the site

ii) 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 1 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

iii) Part 3 of the safety 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

Annex 14 (i) d: Status of Probabilistic Safety Assessments at Each Nuclear Power Plant

Bruce A

The Bruce A Probabilistic Safety Assessment (PSA) was completed in 2003 for Units 3 and 4 return-to-service. Subsequent updates of the Level 1 portion of the PSA in 2004 and 2006 have incorporated design and operational changes, and identification of the systems important to safety as per regulatory standard S-98.

The scope of the Bruce A PSA included the assessment of the public health and economic risks arising from initiating events internal to the NPP. In addition, two externally initiated events were included: loss of off-site power and loss of common service water.

The PSA study made the following principal conclusions:

- The risk to the health and welfare of the population living and working in the vicinity of Bruce A and B from the operation of the Bruce A reactors is significantly lower than other risks to which they are normally exposed.
- The severe core damage frequency of 7.1 x 10^{-5} per reactor per year is acceptably low and similar to that calculated for other contemporary NPP designs.
- The desired risk reductions sought by means of the design and operational changes made for Bruce A's return-to-service have been achieved.
- The likelihood of an accidental release large enough to warrant relocation of members of the public is sufficiently low that it can be considered negligible for all practical purposes. This conclusion is based on the calculated mean frequency of a large off-site radioactive release of 1.6 x 10^{-6} per reactor per year.

Bruce B

The Bruce B PSA was updated and issued in 2004. Its scope included the assessment of the public health and economic risks arising from initiating events internal to the NPP and due to externally initiated loss of off-site power.

The PSA resulted in the following principal conclusions:

- The risk to the health and welfare of the population living and working in the vicinity of Bruce A and B from the operation of the Bruce B reactors is significantly lower than other risks to which they are normally exposed.
- The severe core damage frequency of 2.2×10^{-5} per reactor per year is acceptably low and similar to that calculated for other contemporary NPP designs.
- The likelihood of an accidental release large enough to warrant relocation of members of the public is sufficiently low that it can be considered negligible for all practical purposes. This conclusion is based on the calculated mean frequency of a large off-site radioactive release of 1.8×10^{-7} per reactor per year.

Pickering A

The Level 1 portion of the Pickering A PSA was updated in 2006, incorporating into the estimate of severe core damage frequency all of the design and operational changes made as part of the Pickering A return-to-service projects. It should be noted that many of these design changes were made specifically to reduce the severe core damage frequency and were based on recommendations derived from the 1995 version of the PSA. The Level 2 portion of the PSA has not been updated.

The scope of the Pickering A PSA included the assessment of the public health and economic risks arising from initiating events internal to the NPP. In addition, two externally initiated events were included: loss of off-site power and loss of common service water.

The principal conclusions for the PSA study were as follows:

- The risk to the health and welfare of the population living and working in the vicinity of Pickering A and B from the operation of the Pickering A reactors is significantly lower than other risks to which they are normally exposed.
- The severe core damage frequency of 6.4×10^{-5} per reactor per year is acceptably low and similar to that calculated for other contemporary NPP designs.
- The desired risk reductions sought by means of the design and operational changes made for Pickering A return-to-service have been achieved.
- The likelihood of an accidental release large enough to warrant relocation of members of the public is sufficiently low that it can be considered negligible for all practical purposes. This conclusion is based on the calculated mean frequency of a large off-site radioactive release of 5.0×10^{-8} per reactor per year. This is significantly less than the OPG target of 1.0×10^{-6} per reactor per year.

Pickering B

A PSA for Pickering B was completed and issued in 2006. The scope of the PSA included the assessment of the public health and economic risks arising from initiating events internal to the station and due to two externally initiated events: loss of off-site power and loss of common service water.

The conclusions of the Pickering B PSA were as follows:

- The risk to the health and welfare of the population living and working in the vicinity of Pickering A and B from the operation of Pickering B reactors is significantly lower than other risks to which they are normally exposed.
- The severe core damage frequency of 1.5×10^{-5} per reactor per year is acceptably low and similar to that calculated for other contemporary NPP designs.
- The likelihood of an accidental release large enough to warrant relocation of members of the public is sufficiently low that it can be considered negligible for all practical purposes. This conclusion is based on the calculated mean frequency of a large off-site radioactive release of 9.2×10^{-10} per reactor per year. This is significantly less than the OPG target of 1.0×10^{-6} per reactor per year.

Darlington

The Darlington PSA was completed in 1987 to provide thorough safety design verification, identify initiating events and accident sequences that dominate public risk, and assist in the preparation of operating procedures. The scope of the Darlington PSA included the assessment of the public health and economic risks arising from initiating events internal to the NPP. The study did not include external events or fires.

The conclusions from the Darlington PSA were as follows:

- The quantified accident frequencies and risks are low. The total frequency of all events with the potential for a large off-site release was estimated to be 8.2×10^{-7} per reactor-year.
- The estimated mean risk was 9×10^{-6} Sv/yr to an individual at the site boundary, and 7×10^{-2} person-Sv/yr to the surrounding population.
- Dominant contributors to public risk are sequences that can lead to the bypass of containment.

The Darlington PSA has been partially updated since 1987 and these revisions are being used to support operation. A complete revision is currently under way to reflect changes in design and operation, and changes in risk assessment methodology since the original assessment.

Point Lepreau

A PSA for Point Lepreau is being performed as part of the refurbishment project, and will be completed prior to the unit being returned to service after the refurbishment outage.

The Point Lepreau PSA project includes both Level 1 and Level 2 PSAs for internal events and for external events involving station fires and station flooding. In addition, a shutdown state PSA for internal events and a PSA-based seismic margin assessment are under development.

Gentilly-2

Similar to Point Lepreau, Gentilly-2 does not currently have a full PSA. Various probabilistic studies were done as part of the original station design verification (known as safety design matrices), and reliability models have been developed for various systems important to safety. A full Level 2 PSA will be done if the decision is made to refurbish Gentilly-2 for continued operation.

Annex 15 a: Requirements and Guidance for Control of Radiation Exposure of Workers and the Environment

The regulations associated with the *Nuclear Safety and Control Act* (NSCA), include one set on radiation protection. The *Radiation Protection Regulations* include many of the ICRP-60 (1991) recommendations for dose limits, as well as ICRP-65 (1994) recommendations pertaining to occupational exposure to radon progeny.

The *Radiation Protection Regulations* address the following:

- implementation and requirements of licensee radiation protection programs;
- the requirements for recording of doses;
- the definition of action level and the actions to be taken when an action level has been reached;
- informing workers of the risks associated with radiation to which the worker may be exposed, and informing workers of effective and equivalent dose limits;
- the requirement to use licensed dosimetry services;
- effective and equivalent dose limits for nuclear energy workers, pregnant nuclear energy workers and persons who are not nuclear energy workers;
- dose limits that apply during the control of nuclear emergencies;
- actions to be taken when a dose limit is exceeded, and authorization of return to work;
- requirements for licensed dosimetry services;
- requirements for labelling of containers and devices; and
- requirements for posting of signs at boundaries and points of access.

The NSCA gives the Commission the power to authorize the return to work of persons who have exceeded a dose limit.

The CNSC has developed a number of regulatory documents to assist licensees in matters related to radiation protection and environmental protection. Regulatory Guide G- 129, Rev. 1, *Keeping Radiation Exposures and Doses "As Low As Reasonably Achievable (ALARA)"*, describes measures licensees can take to keep all doses to persons as low as reasonably achievable, social and economic factors being taken into account (ALARA). The elements that the CNSC considers to be essential in the approach to ALARA are summarized as follows:

- a demonstrated management commitment to the ALARA principle;
- the implementation of ALARA through a licensee's organization and management, provision of resources, training, establishment of action levels, documentation and other measures; and
- regular operational reviews.

CNSC regulatory guide G-228 *Developing and Using Action Levels* 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*. Under the *Radiation Protection Regulations*, an action level is defined 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." G-228 provides guidance on the types of parameters that can be used in developing action levels, requirements for monitoring these parameters, and appropriate responses when an action level is reached.

Nuclear energy workers must be monitored for radiation exposure through a CNSC licensed dosimetry service. CNSC regulatory standard S-106 rev.1 *Technical and Quality Assurance Requirements for Dosimetry Services*, contains accuracy, precision and QA requirements for dosimetry services licensed by the CNSC. S-106 either meets or exceeds the requirements of IAEA safety Guide *Assessment of*

Occupational Exposure Due to Intakes of Radionuclides (RS-G-1.2, 1999) and *Assessment of Occupational Exposure Due to External Sources of Radiation* (RS-G-1.3, 1999). Occupational dose results are submitted by the dosimetry service on a quarterly basis to the Canadian National Dose Registry maintained by Health Canada.

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 matter consistent with Canadian environmental policies, acts and regulations and with Canada's international obligations.

For a complete list of CNSC regulatory documents, please visit the CNSC Web site at http://www.nuclearsafety.gc.ca

Annex 15 c: Doses to Personnel at Canadian Nuclear Power Plants

The CNSC *Radiation Protection Regulations* reflect the 1990 recommendations of the International Commission on Radiological Protection (ICRP 60). Workers at Canadian nuclear power plants (NPPs) are restricted by dose limits of 50 mSv in any one year and 100 mSv in a five-year period.

The data provided by the National Dose Registry in the following table present the average annual worker dose, the collective dose and the maximum worker dose at Canadian NPPs for the period of 2001–2005. As indicated, no worker has exceeded the annual dose limit of 50 mSv. In addition, although not indicated in the table, no worker has exceeded the five-year dose limit of 100 mSv.

Occupational Dose Summary from 2001 to 2005

	Year	**# of Reactors**	**Average Effective Dose**	**Collective Dose**	**Maximum Individual Dose**
			(mSv)	Person-Sievert	(mSv)
Bruce A & B	2001	4	1.10	6.51	24.13
	2002	4	1.04	7.05	22.59
	2003	5	0.86	6.08	15.86
	2004	6	0.91	5.46	18.78
	2005	6	1.17	6.82	19.99
Darlington	2001	4	0.52	2.14	12.31
	2002	4	0.47	1.98	10.92
	2003	4	0.71	3.41	12.89
	2004	4	0.43	1.89	8.78
	2005	4	0.61	2.88	12.44
Gentilly-2	2001	1	0.47	1.18	17.33
	2002	1	0.64	1.52	15.54
	2003	1	1.21	3.02	23.27
	2004	1	0.12	0.25	9.1
	2005	1	0.59	1.51	15.85
Pickering A & B	2001	4	0.62	5.14	14.33
	2002	4	0.62	5.74	17.23
	2003	5	0.57	5.10	14.05
	2004	5	0.73	6.60	14.94
	2005	6	1.11	11.04	17.85
Point Lepreau	2001	1	0.49	0.64	12.89
	2002	1	0.73	1.32	15.17
	2003	1	0.84	1.15	14.08
	2004	1	0.66	0.92	14.46
	2005	1	1.11	1.58	17.86

Collective Dose at Canadian Nuclear Power Plants

Year	# of Reactors	Collective Dose (Person-Sievert)
2001	14	10.37
2002	14	17.61
2003	16	18.75
2004	17	15.09
2005	18	23.82

Annex 15 d: Radiological Emissions from Canadian NPPs

All NPPs release small quantities of radioactive material s in a controlled manner into both the atmosphere (as gaseous effluents) and adjoining water bodies (as liquid effluents). This annex reports the magnitude of these releases for each operating NPP in Canada for three years (2003 to 2005). This annex also indicates how these releases compare with the limits imposed by the CNSC. The data show that, in almost all the cases, the levels of gaseous and liquid effluents from all currently operating NPPs are below 1% of the values authorized by the CNSC.

Radioactive material released into the environment through gaseous and liquid effluents from NPPs can result in radiation doses to members of the public through direct irradiation. Such doses are subject to statutory dose limits for members of the public, which are set out in the CNSC *Radiation Protection Regulations*. The regulatory dose limit for members of the public is an effective dose of 1 mSv.

The doses received by members of the public from routine releases from NPPs are too low to measure directly. Therefore, to ensure that the public dose limit is not exceeded, the CNSC restricts the amount of radioactive material that licensees may release. These effluent limits are derived from the public dose limit and are referred to as “derived release limits” (DRLs). In addition, the industry sets operating targets that are a small percentage of the derived release limits. These targets are based on the ALARA principle and are unique to each facility, depending on the individual factors.

As methods of calculating DRLs become more sophisticated, it becomes necessary for licensees to revise their DRLs. At the same time, licensees review the assumptions affecting the exposure of critical groups; for example, location and lifestyle habits of critical groups and the location of dairy farms. In addition, licensees may use more site-specific data obtained from their routine environmental monitoring programs, such as liquid dispersion factors or surveys of the local population. The net effect of these changes on the methodology for calculating DRLs has been that some limits increased while others decreased, depending on the relative importance of the various pathways. As new information on dose calculation methods or parameters becomes available, the DRLs may require subsequent revisions. In addition, since the DRLs are based on the regulatory public dose limit, changes in the regulatory limits may also produce changes in the DRLs.

The various DRLs for Canadian NPPs, as well as the actual gaseous and liquid effluent releases from these NPPs, are included in the following tables. These tables indicate that the releases are, in the majority of cases, below 1% of the DRLs for the corresponding NPPs.

Gaseous Effluent Release from Canadian Nuclear Power Plants (2003 to 2005)

	Tritium Oxide (TBq)	Carbon-14 (TBq)	Nobel Gases (TBq-Mev)	Iodine-131 (TBq)	Particulates (TBq)
Bruce A [1]					
DRL, Since 2001	8.8 E04	5.7 E02	5.0 E04	1.2 E00	2.1 E00
2003	1.9 E02	5.1 E-01	1.4 E01	2.1 E-06	2.9 E-06
2004	6.7 E02	1.2 E0	5.0 E01	3.8 E-05	3.5 E-06
2005	3.6 E02	1.6 E0	4.1 E01	1.4 E-05	4.5 E-06
Bruce B[1]					
DRL, Since 2001	9.3 E04	6.0 E02	1.2 E05	1.3 E00	2.5 E00
2003	3.7 E02	4.3 E0	5.1 E01	3.2 E-05	1.1 E-04
2004	1.9 E02	2.6 E0	5.6 E01	3.9 E-05	1.1 E-04
2005	3.7 E02	8.8 E0	5.3 E01	3.2 E-05	9.8 E-05
Darlington[1]					
DRL, 2001 Since 2005	4.6 E04 4.3 E04	1.5 E02 1.8 E03	3.1 E04 3.9 E04	3.3 E-01 4.7 E00	9.4 E-01 2.4 E00
2003	1.7 E02	3.5 E0	1.3 E01	1.4 E-04	6.9 E-05
2004	2.8 E02	1.9 E0	1.9 E01	1.3 E-04	8.0 E-05
2005	1.3 E02	1.6 E0	1.7 E01	1.2 E-04	7.8 E-05
Gentilly[2])					
DRLs	4.4 E05	8.8 E02	1.7 E05	1.3 E00	1.9 E00
2003	1.5 E02	3.9 E-01	7.1 E-01	Not detected	5.4 E-06
2004	1.2 E02	2.2 E-01	7.1 E-01	Not detected	7.4 E-06
2005	1.6 E02	2.2 E-01	6.6 E-01	Not detected	9.4 E-06
Pickering A[1]					
DRL, Since 2001	7.0 E04	1.8 E03	1.7 E04	2.2 E-00	1.2 E-00
2003	1.7 E02	1.1 E0	2.8 E02	6.4 E-05	3.4 E-04
2004	2.1 E02	1.2 E0	2.8 E02	6.9 E-05	3.5 E-04
2005	1.7 E02	8.4 E-01	1.2 E02	6.1 E-05	1.2 E-04
Pickering B[1]					
DRL, Since 2001	7.0 E04	1.8 E03	1.7 E04	2.2 E00	1.2 E00
2003	3.3 E02	2.6 E0	2.0 E02	9.7 E-05	1.6 E-05
2004	3.8 E02	1.6 E0	2.1 E02	9.7 E-05	1.3 E-05
2005	3.3 E02	3.9 E0	8.7 E01	6.0 E-05	8.9 E-06
Point Lepreau					
DRL	4.3 E05	3.3 E03	7.3 E04	2.2 E01	5.4 E00
2003	1.0 E+02	2.1 E-01	2.5 E+00	Not detected	Not detected
2004	1.30 E+02	9.10 E-01	3.0 E+00	Not detected	Not detected
2005	1.70 E+02	2.80 E-01	5.3 E+00	Not detected	Not detected

[1]: Since 2001, OPG and Bruce Power have reported the DRLs as interim DRLs. They were revised in 2001 mainly in response to changes in the public dose limit. They will be replaced when a more comprehensive revision has been completed. Darlington has revised the interim DRLs in 2005 and adopted the comprehensive new DRLs since then.

[2]DRLs for Gentilly-2 are based on 5 mSv/a.

Liquid Effluent Release from Canadian Nuclear Power Plants (2003 to 2005)

	Tritium Oxide (TBq)	Gross Beta-Gamma (TBq)	Carbon-14 (TBq)
Bruce A			
DRL, Since 2001	4.5 E04	5.8 E-01	1.1 E01
2003	6.0 E01	8.8 E-04	1.7 E-03
2004	9.9 E01	8.1 E-04	5.7 E-03
2005	1.6 E+02	8.9 E-04	8.2 E-03
Bruce B			
DRL, Since 2001	6.0 E05	4.9 E00	9.1 E01
2003	8.0 E02	6.1 E-03	6.5 E-3
2004	4.8 E02	2.5 E-03	8.5 E-03
2005	2.6 E+02	2.9 E-03	6.0 E-03
Darlington			
DRL, Until 2001 Since 2005	8.8 E05 4.3 E06	2.6 E01 7.1 E01	6.0 E02 9.7 E02
2003	1.0 E02	7.3 E-03	1.2 E-03
2004	1.6 E02	5.7 E-03	4.3 E-04
2005	2.2 E02	7.8 E-03	2.8 E-04
Gentilly			
DRL	1.2 E06	5.3 E00	1.0 E02
2003	3.5 E02	8.6 E-04	3.0 E-2
2004	1.4 E02	3.8 E-04	1.5 E-02
2005	2.7 E02	7.8 E-04	2.3 E-02
Pickering A			
DRL, since 2001	1.7 E05	2.0 E00	See Note 1
2003	6.8 E01	3.1 E-03	
2004	1.0 E02	2.1 E-03	
2005	8.2 E01	2.3 E-03	
Pickering B			
DRL, since 2001	1.7 E05	2.0 E00	2.6 E01
2003	1.9 E02	7.0 E-03	1.1 E-02
2004	1.7 E02	7.0E-03	4.4 E-03
2005	1.8 E02	1.3 E-02	5.5 E-03
Point Lepreau			
DRL	1.6 E07	1.5 E01	3.0 E02
2003	8.1 E+01	1.4 E-03	1.8 E-03
2004	9.6 E+01	2.4 E-03	1.30E-02
2005	2.1 E+02	1.60E-03	1.70E-03

Note 1: Since 1999, carbon-14 releases in liquid effluent from Pickering A have been reported in the carbon-14 liquid release data for Pickering B.

Annex 16.1 b: On-Site Emergency Plans at Canadian Nuclear Power Plants

Bruce Power Nuclear Emergency Plan

The Bruce Power 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 Emergency Plan deals with emergency situations that occur at Bruce A or Bruce B that endanger the safety of on-site staff or impact the protection of the environment and protection of the public. The emergency plan was conceived to deal predominantly with releases of radioactive materials from fixed facilities and the interfaces with the Province of Ontario Nuclear Emergency Response Plan (PNERP) (see Annex 16.1 c). However, the infrastructure that is defined in the Bruce Power Emergency Plan can be used in the planning and response to virtually all potential emergencies at the Bruce Power site.

Security (or hostile action) response is dealt with through separate provisions, but provisions of this emergency plan still apply to deal with the associated potential threat of release of radioactive material (e.g., the need for off-site notification, situation updates, confirmation of any radioactive releases, etc.). Emergency response related to transportation of nuclear substances is addressed by a separate plan.

The Bruce Power Emergency Plan defines a station emergency as a sudden, unexpected occurrence of unusual radiological conditions with the potential for accidental exposure to staff or public exceeding regulatory limits. A station emergency can also be declared for a non-radiological event requiring protection of on-site personnel and activation of Bruce Power's emergency response organization to deal with the event.

The emergency plan is consistent with the corresponding Bruce Power nuclear safety analysis and reports that were provided to the CNSC in support of individual applications for CNSC construction and operating licences. To implement its emergency plan, Bruce Power has developed specific nuclear emergency preparedness and response arrangements for its stations.

In the event of an on-site 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 off-site implications, Bruce Power staff further categorizes it according to criteria contained in the PNERP. To simplify this step, many events have been categorized according to the Province of Ontario notification designations.

Emergency drills and exercises are an integral part of Bruce Power's overall process of program assessment. These exercises are conducted periodically at Bruce Power's NPPs, in cooperation with other organizations and jurisdictions that have a role in nuclear emergency preparedness and response.

Bruce Power maintains emergency public response capabilities within various communications departments including Employee Communications, Investor and Media Relations, Government Relations and Community Relations. The primary targets of Bruce Power's nuclear emergency public information program are those who live or work near Bruce Power NPPs, and select Bruce Power employees and contacts who need to know. In the event of a nuclear emergency involving a Bruce Power NPP, Bruce Power emergency response procedures and agreements require the corporation to coordinate its public information efforts and activities with those of other participating jurisdictions or organizations, such as provincial agencies operating within the framework of the PNERP. Bruce Power's communications response in a given emergency will depend upon the related circumstances.

For events that are not severe enough to warrant activation of the PNERP, but may interest neighbours and other stakeholders, Bruce Power issues news releases and/or verbal briefings to the local media, with copies to provincial and municipal officials. If the situation warrants, Bruce Power may activate its local media centre for briefing or interview purposes.

More severe events may require the activation of the PNERP and the Province’s joint emergency information centre (EIC) which is located in the Toronto offices of Emergency Management Ontario. Pending activation and operation of the EIC, Bruce Power's emergency response organization will, on an interim basis, communicate relevant information to the public and the media. With the EIC in operation, the provincial government assumes control of information services regarding the off-site response. The Municipality of Kincardine will establish a local EIC at the Municipality of Kincardine offices. Bruce Power assists the Municipality of Kincardine with the preparation of information to the local public to ensure accuracy. Emergency-related information prepared for issue at the local and provincial EICs is jointly scrutinized for accuracy by all three parties prior to its release.

Ontario Power Generation Consolidated Nuclear Emergency Plan

The OPG Consolidated Nuclear Emergency Plan is a corporate-level plan that serves as the common basis of site-specific nuclear emergency preparedness and response arrangements at OPG's Darlington and Pickering stations. It describes concepts, structures, roles and processes to implement and maintain an effective OPG response to radiological emergencies that could endanger on-site staff, the public, or the environment. It is designed to be compatible with the PNERP.

The OPG Consolidated Nuclear Emergency Plan defines a nuclear power plant emergency as a sudden, unexpected occurrence of unusual radiological conditions that have the potential to expose staff or public to radiation in excess of regulatory limits.

The OPG plan focuses on the release of radioactive materials from fixed facilities and on OPG interfaces with the PNERP (see Annex 16.1 c). The formal scope of the plan excludes hostile (security) action incidents at OPG nuclear plants, as these incidents are dealt with in detail in other OPG documents. However, the plan's provisions regarding potential releases of radioactive materials also apply to security incidents. These include the requirements for off-site notifications, situation updates and confirmations of any radioactive releases.

The emergency plan is consistent with the corresponding OPG nuclear safety analyses and reports that were provided to the CNSC in support of individual applications for CNSC construction and operating licences. To implement its nuclear emergency plan, OPG has developed site-specific nuclear emergency preparedness and response arrangements for its stations.

In the event of an on-site nuclear emergency at an OPG NPP, OPG staff would immediately classify the nuclear emergency in accordance with criteria specified in the station emergency procedure. Should this emergency have off-site implications, OPG staff further categorizes it according to criteria contained in the PNERP. To simplify this step, many events have been categorized according to Province of Ontario notification designations.

Emergency drills and exercises are an integral part of OPG's overall process of program assessment. Exercises are conducted periodically at all OPG power reactor installations, in cooperation with other organizations and jurisdictions that have a role in nuclear emergency preparedness and response.
OPG maintains emergency public response capabilities within its nuclear public affairs department. The primary targets of OPG's nuclear emergency public information program are those who live or work near OPG NPPs. In the event of a nuclear emergency involving an OPG NPP, OPG emergency

response procedures and agreements require the corporation to coordinate its public information efforts and activities with those of other participating jurisdictions or organizations, such as provincial agencies operating within the framework of the PNERP. The OPG public affairs response in a given emergency will depend upon the related circumstances.

For events that are not severe enough to warrant activation of the PNEP, but may interest neighbours and other stakeholders, OPG issues news releases or verbal briefings to the local media, with copies to provincial and municipal officials. If the situation warrants, OPG may activate its on-site or near-site Media Centre for briefing or interview purposes.

More severe events may require the activation of the PNERP and the Province’s joint EIC. Pending activation and operation of the EIC, OPG's emergency response organization will, on an interim basis, communicate relevant information to the public and the media. With the joint EIC in operation, the provincial government assumes control of information services regarding the off-site response. OPG provides training, financial and personnel assistance to the joint EIC.

Gentilly-2 Nuclear Emergency Plan

The Hydro-Québec “Plan des mesures d'urgence” describes the utility's arrangements to cope with actual or potential nuclear emergencies at its Gentilly-2 NPP. This publication and various supporting documents define the Gentilly-2 nuclear emergency preparedness and response plan in detail, including application criteria, roles and responsibilities, requirements for coordination, classification of emergency alerts, 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 on-site events that increase the radiological risk to employees, the public or the environment shall be announced by the declaration of an appropriate level of radiation alert, indicating the severity or potential severity of the incident.

An area alert is to be declared when the radiation field or concentration of airborne contamination over a localized on-site area increases to 2 to 10 times normal levels or when these risks are increasing unusually rapidly. A site alert is to be declared when radiological conditions pose a general, significant risk to Gentilly-2 site personnel. A general alert is to be declared following radiological releases in excess of regulatory limits, or after releases that could result in radiation exposures in excess of dose limits.

Should abnormal events or conditions at Gentilly-2 lead to a potential, or an actual off-site nuclear emergency, the “directeur du Comité de gestion du centre d'urgence d'Hydro-Québec”, is responsible for notifying the “Organisation de la Sécurité Civile du Québec (OSCQ)” of the threat or emergency. The OSCQ would lead any necessary off-site nuclear response.

Hydro-Québec management, the “Groupe Communications et relations avec le milieu” (GCRM) in nearby Trois-Rivières, and communications staff at the Gentilly-2 emergency centre cooperates to provide information to site personnel, the public and the media. In the case of a General Alert, the GCRM move to the “Centre de coordination des communications de l'OSCQ” where “Communication-Québec” coordinates all public relations for the government of Québec.

The Gentilly-2 plant conducts radiation emergency drills at least once per year. It also participates in externally organized drills, in cooperation with international, national, and provincial agencies and organizations. 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 off-site authorities;
- maintenance and development of communication and public relation framework;
- training;
- drills and exercises;
- emergency preparedness implementation (risk assessment, alert declaration, emergency response organization activation, off-site authorities notification, management, intervention, accident assessment, staff protection, recommendation of protection measures to the population, end of alert and return to normal); and
- evaluation of the emergency preparedness process.

The emergency preparedness process comprises these major outputs:

- policy and framework documents;
- emergency procedures;
- collaboration and agreements with off-site authorities;
- emergency response organization;
- emergency installations and equipments; and
- tested emergency plans.

Point Lepreau Emergency Preparedness

NBPN provides emergency preparedness services in accordance with a process defined within the Point Lepreau nuclear management system. The process provides the capability to respond to radiological and conventional emergencies in a timely, effective and coordinated manner. The process scope includes all activities required for the preparation for, and response to, emergencies that could impact station personnel, the public or the environment, including necessary coordination with external organizations required to support any emergency response. The types of emergencies covered include radiation events involving releases on site and to the environment (including transportation accidents involving nuclear substances), fire, chemical, medical, security incidents and natural disasters such as storms, floods and earthquakes.

The New Brunswick Emergency Measures Organization (NBEMO), an agency of the provincial government, is responsible for actions to protect the public, and has processes for developing and testing the capability of its own plans and the coordinated response of other government agencies. The Point Lepreau process interfaces with the NBEMO plans and assists off-site authorities in dealing with radiation protection aspects of the NBEMO plan.

The Point Lepreau emergency preparedness process includes these key activities:

- preparation of the basis for emergency planning;
- development and modification of the emergency response plan;
- determining the resources required to implement the plan;
- development of emergency response procedures;
- implementing, maintaining and testing the response capabilities;
- recognizing events that require emergency response;

- mitigating the effects of events; and
- recovery from events in which emergency response was deployed.

Inputs in to the process include:

- assessment of potential emergency scenarios arising from the station design and safety basis, station activities and materials;
- coordination requirements with external emergency respondents and agencies; and
- relevant emergency planning and response legislation, regulations, standards and best practices, including standards and guidance from the Canadian Standards Association, National Fire Protection Association (NFPA), ICRP and IAEA.

Outputs from the process are:

- tested emergency plans;
- information for the public;
- respondent emergency procedures; and
- maintained and designated emergency facilities and equipment

The emergency plan has three escalating levels of response to an incident requiring prompt response action:

- alert: requires intervention of a trained response team, but is not of sufficient magnitude to interfere with activities throughout the station
- site area emergency: emergency conditions affecting the site area only, within the NBPN Point Lepreau property boundaries
- general emergency: emergency conditions affecting the environment or potentially affecting the health and safety of persons outside the station property boundary

Annex 16.1 c: Provincial Off-Site Emergency Plans

Province of Ontario

The province of Ontario possesses the greatest number of commercial power reactors (20) of any jurisdiction in Canada. In addition, a research reactor is located at Chalk River, and six U.S. nuclear facilities lie within 80 km of the province. As a result of these hazards, a nuclear emergency plan has been in place at the provincial level since 1986 (the Province of Ontario Nuclear Emergency Response Plan - PNERP). This plan has never been fully or partially activated, although events have occurred which resulted in formal notifications to the Province. These events were monitored until it was determined that they posed no risk to the public or environment.

The *Emergency Management and Civil Protection Act* governs emergency preparedness and response in Ontario. This legislation requires the government to formulate an emergency plan for emergencies arising in connection with nuclear facilities. It also permits the Province to designate municipalities that shall plan for nuclear emergencies. Emergency Management Ontario (EMO) on behalf of the Province of Ontario, administers the PNERP and coordinates nuclear emergency preparedness and response in Ontario.

The PNERP defines a nuclear emergency to occur when there is an actual or potential hazard to public health and property or to the environment from ionizing radiation or from a nuclear power plant (NPP). The hazard may be caused by an accident, malfunction, or loss-of-control involving nuclear substances or a 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 off-site nuclear emergency preparedness and response, coordinates the activities of provincial ministries, nuclear facilities, the Government of Canada (including the CNSC), and designated municipalities in order to meet the objectives.

The PNERP details the arrangements in place for nuclear emergency planning, preparedness and response in Ontario. The plan covers various components, which include the following:

- aim and guiding principles;
- hierarchy of emergency plans and procedures;
- description of the hazard;
- planning basis;
- protective actions;
- concept of operations;
- emergency organization;
- operational policies;
- emergency information;
- public education;
- detailed responsibilities of the various participants; and
- provincial and municipal committee oversight.

Full-scale provincial exercises focussing on nuclear or radiological emergencies are conducted regularly with participation from the Government of Canada.

During the reporting period, the following reforms were undertaken to keep EMO in line with the best international practices:

1. Legislation, policies and operational framework were upgraded to ensure a shift from voluntary to mandatory establishment of programs and plans.

2. The accountability process at the municipal and provincial levels was strengthened.

3. The essential-level emergency management programs were implemented by provincial ministries and municipalities. In the next phase, EMO will work with its stakeholders to ensure that they have access to Ontario's recommended practices and tools for a comprehensive, risk-based emergency management program.

4. Hazard identification and risk assessment was incorporated in the planning process.

5. The emergency management approach from preparedness and response was broadened to also include mitigation/prevention and recovery, in harmony with the best international practices.

6. EMO's capability to respond to widespread, prolonged and complex emergencies was increased significantly. This included doubling the strength of EMO staff, reorganizing and restructuring of EMO and establishment of continual operational capability through duty officers and duty managers.

7. The nuclear-designated communities, nuclear facilities and other stakeholders were extensively consulted with a view to improving the existing off-site emergency management plans and procedures (including public alerts, administration of potassium iodide pills, evacuation strategy and notification procedures).

Province of Québec

Within the province of Québec, the "Organisation de la sécurité civile du Québec" (OSCQ) is responsible for emergency planning and response to all hazards, including off-site nuclear emergencies. The "Plan national de sécurité civile du Québec" (PNSC) provides the terms of reference for all emergencies. The nuclear component of the OSCQ plan is described in a document entitled "Plan des mesures d'urgence nucléaire externe à la centrale nucléaire Gentilly-2" (PMUNE-G2), in accordance with the Québec provincial bill "*Loi sur la sécurité civile*" (Civil Protection Act).

The PMUNE-G2 clearly defines the government agencies' responsibilities in a nuclear emergency at the Gentilly-2 site, with the objectives of minimizing the consequences, protecting the public and providing support to the municipality's authorities. In effect since 1983, the PMUNE-G2 is updated regularly. In 2002, response procedures and support programs were edited, and are currently being implemented. Under the PMUNE-G2, HQ and the OSCQ have separate but complementary responsibilities for emergency planning and response to an accident at the Gentilly-2 site. As part of this response, the OSCQ would open the government operations centre) to coordinate the actions of the various government departments and organisations in Québec, to maintain a link with the federal jurisdictions and to provide support to the affected municipalities.

A new preventive information campaign on the nuclear related risks took place in March 2007 in parallel with the distribution of new potassium iodine pills to residents and workers in the urgent protective action planning zone within an 8 km radius around the Gentilly-2 NPP. The Web site www.urgencenucleaire.qc.ca is still accessible. Furthermore, the municipalities within the 8-km zone are evaluating the procurement of an early population warning system. Between 2002 and 2005, the Province of Québec purchased special detection and analysis equipment capable of characterizing the environment and the food chain. Emergency response participants who need to use them have also completed relevant training and exercises. The PMUNE-G2 master plan is being revised. The new version should be available at the beginning of 2008.

Province of New Brunswick

The provincial nuclear emergency program is governed by a partnership between NBPN and the New Brunswick Department of Public Safety, which is the lead provincial department for public safety and public security. Its primary agencies for emergency management and public security in New Brunswick are as follows:

- The New Brunswick Emergency Measures Organization (NBEMO), which is the provincial lead agency for emergency management and business continuity, including radiological-nuclear contingencies
- The New Brunswick Security and Emergencies Directorate (NBSED), which is the provincial lead agency for security and critical infrastructure protection

During the reporting period, the Government of New Brunswick 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.

Recent major exercises include Ardent Sentry 2006 (Canada-US national security exercise), Exercise Maritime Response 2006 (federal-provincial radiological response exercise), and Intrepid 2006 (provincial nuclear exercise).

The NBEMO is currently developing a provincial Radiological Emergency Plan, for non-nuclear events. Under the Emergency Measures Act, the NBEMO has the lead responsibility to develop provincial emergency action plans, and to direct, control and coordinate emergency responses.
The New Brunswick Emergency Measures Plan, prepared by NBEMO, defines an emergency as any abnormal situation requiring prompt action beyond normal procedures to limit damage to persons, property or the environment. The stated aim of the plan is to designate responsibility for actions to mitigate the effects of any emergency, other than war, in the province of New Brunswick.

The plan defines the lead responsibilities of the Department of Public Safety and the supporting roles of some 23 departments, agencies or organizations. Representatives of these players make up the Provincial Emergency Action Committee (PEAC), which directs, controls and coordinates provincial emergency operations, and assists and supports municipalities as required.

The PEAC maintains two states of readiness. The standby state is a state of readiness that requires representatives of departments to be available on call. An emergency state is a state requiring action from NBEMO and/or other departments. During an emergency state, departmental representatives are called to headquarters and briefed on the corresponding emergency.

The province of New Brunswick is divided into 11 emergency measure organization (EMO) districts. EMO district coordinators stimulate the development and refinement of emergency planning by municipalities, and provide advice and assistance on the development of emergency plans. They coordinate the use of provincial resources to deal with emergency situations in rural areas and urban municipalities. To accomplish this, district emergency committees are formed to provide assistance to municipalities and the populace of unincorporated areas. These committees consist of representatives from the departments of Environment, Health, Justice, Natural Resources, Social Services and Transportation, as well as local governments.

Local authorities are responsible for emergency planning and response within their physical boundaries, and in some cases, for certain areas outside their boundaries. Communities may assist each other in accordance with mutual aid agreements. However, when an emergency arises in which the resources of a community, or group of communities are insufficient, the province will provide assistance through the district emergency committee. District emergency operations centres are located in government facilities.

The NBEMO developed the Point Lepreau Off-site Emergency Plan in accordance with the framework described above. It delineates the roles and responsibilities of, and the immediate actions to be taken by, those involved if an incident at Point Lepreau creates an off-site emergency.

If it is necessary to alert the public to the occurrence of an off-site emergency, wardens will oversee designated areas to ensure residents are appropriately informed of any actions required of them. Radio, television and wardens will advise the public of the need for any protective actions. Arrangements are in place to help individuals who may require physical assistance should evacuation prove necessary.

During the reporting period, the Government of New Brunswick consolidated public safety and public security responsibilities under the mandate of the Department of Public Safety.

The Province established the Security and Emergencies Initiative, comprising work on Nuclear Emergency Preparedness and several other areas. The highlights are as follows:

1. strengthening the prevention, preparedness and response for all hazards, including the integration of crisis and consequence management apparatus under a single emergency management system

2. investing significantly in provincial government internet infrastructure to make it more reliable, more fault-tolerant and to improve capacity

3. updating and strengthening operational capability at the provincial (NBEMO) Joint Emergency Operations Centre, including enhancements to the business process, investments in infrastructure to improve connectivity and collaboration among federal and provincial intervening organizations, and more focus on operational readiness

4. development of a training and exercise strategy for major scenarios, including nuclear response, so that the provincial nuclear emergency organization exercised annually, rather than every three years (as in the past)

5. replacing the inventory of potassium iodide pills, updating demographic information for the Emergency Planning Zone and improving communications systems linking the Off-Site Emergency Centre and the Joint Emergency Operations Centre

Annex 16.1 d: Provisions of Federal Emergency Plans

Provisions of the Federal Nuclear Emergency Plan

Within the Federal Nuclear Emergency Plan (FNEP), a nuclear emergency is defined as an event that has led or could lead to a radiological threat to public health and safety, property, and the environment. The FNEP contains the following information:

- outlines of the Government of Canada's aim, authority, emergency organization, and concept of operations for dealing specifically with the response phase of a nuclear emergency;
- a description of the framework of federal emergency preparedness policies, the planning principles on which the FNEP is based and the links with other specific documents of relevance to the FNEP;
- a description of the specific roles and responsibilities of participating organizations that are involved in the planning, preparedness or response phases of a nuclear emergency; and
- annexes that describe interfaces amongst federal and provincial emergency management organizations, and the arrangements for a coordinated response and the provision of federal support to provinces affected by a nuclear emergency.

There are four types of nuclear emergency events covered by the FNEP:

- an event at a NPP in Canada or in the US along the Canada-United States border;
- an event involving vessels visiting Canada or in transit through Canadian waters;
- an event involving a NPP in the southern US or in a foreign country; and
- other serious radiological events.

In addition to the events listed above, the FNEP includes appendices that summarize the on-site emergency notification classifications adopted by Chalk River Laboratories in Ontario, all NPPs in Canada, and selected NPPs in the United States for both airborne and liquid releases.

The scope of the FNEP excludes the following situations:

- circumstances of war, such as the military use of nuclear weapons against North America;
- events that may pose a limited radiological threat and consequently are not expected to exceed the response capabilities of regulatory, local or provincial authorities; and
- management and coordination of the Government of Canada's actions during the recovery phase; if federally assisted recovery actions are required as a consequence of a nuclear emergency, responsibility for these actions is to be assigned to a specific minister of the Government of Canada, during or immediately following the response phase of the nuclear emergency.

Québec, Ontario, Nova Scotia, New Brunswick and British Columbia are the Canadian provinces most likely to be affected by a nuclear emergency, as defined in the FNEP. This higher probability is due to their closer proximity to American and Canadian NPPs, and the existence, in some cases, of NPPs within their boundaries, or having ports which are visited by nuclear-powered vessels.

As the Chernobyl accident demonstrated, a severe nuclear emergency at a major NPP that is distant from Canada would have a limited effect. Small quantities of radioactive material might reach Canada. Although these materials could exist in detectable amounts, they would be unlikely to pose a direct (for example, from exposure to fallout) threat to Canadian residents, property or environment. Consequently, Canada's response under the FNEP to a nuclear accident at an NPP in the southern United States or in another foreign country would likely focus on the following:

- controlling food imported from areas near the accident;
- assessing the impact on Canadians living or travelling near the accident site;

- assessing the impact on Canada and informing the public; and
- coordinating responses or assistance to foreign jurisdictions and organizations, national or international.

The potential severity of other serious radiological events, as defined in the FNEP, will depend on case-specific factors. For fixed facilities and materials in transit, appropriate responses to possible emergencies can be planned in some detail. In other situations, emergency planning can be complicated by factors such as the potential magnitude and diversity of the radiation threat, the location of the source of the radiation, any impacts on essential infrastructures, and the speed at which related circumstances may evolve.

Provisions of the Regulatory Body in Emergency Preparedness and Response

The CNSC participates in nuclear emergency planning, preparedness, and response activities as part of its responsibilities according to Canadian legislation.

During a nuclear emergency in Canada, the CNSC would continue in its regulatory role, as anticipated in the Federal Nuclear Emergency Plan (FNEP) and the CNSC Emergency Response Plan.

Since the CNSC's regulatory obligations extend to a wide range of circumstances, stations, activities and materials, it must plan for its possible involvement in a similarly diverse range of emergency scenarios. The CNSC maintains an Emergency Operations Centre (at its headquarters in Ottawa) to enhance its ability to respond to nuclear emergencies. This facility is being used during ongoing FNEP and CNSC drills and training exercises to confirm nuclear emergency preparedness.

In keeping with national policy, and notwithstanding its participation in the FNEP, the CNSC last revised its Emergency Response Plan in November 2001. As mentioned in Article 16, the CNSC is revising the plan again as one of the improvements to the CNSC nuclear emergency management program. The CNSC Emergency Response Plan is the document that describes the strategies and guidelines that the CNSC will follow to cope with a nuclear emergency. It describes:

- emergency situations that could require CNSC involvement;
- the role of the CNSC in nuclear emergencies;
- the role of interfacing parties;
- the CNSC emergency preparedness organization;
- the concept of operations;
- the CNSC equipment infrastructure; and
- 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 *Nuclear Safety and Control Act* (NSCA) and its regulations and the federal *Emergency Preparedness Act*. The plan is designed to provide a compatible interface with the emergency plans and procedures of CNSC licensees, provincial governments, the Government of Canada and international organizations. The plan draws upon provisions of the *Packaging and Transport of Nuclear Substances Regulations* and the *Transportation of Dangerous Goods Act* and regulations, and it includes formal agreements with various organizations and jurisdictions.

Ultimately, implementation of the CNSC Emergency Response Plan in the event of a declared emergency could involve the following parties:

- the CNSC emergency organization
- CNSC employees
- CNSC licensees

- transporters, shippers and others involved in, or affected by, the transport of nuclear substances
- departments and agencies of the Government of Canada
- provincial government departments and agencies
- news media organizations
- the United States Nuclear Regulatory Commission
- the IAEA

The CNSC plan is in effect at all times, in one of four operating modes: normal, standby, activated, or recovery.

- In the normal mode, the CNSC plans, trains and exercises to maintain its emergency preparedness. In this mode, the CNSC also responds to events which do not warrant activation of the emergency organization.
- In standby mode, the CNSC alerts responders and monitors the status of events which may require an emergency response at some stage.
- The CNSC Emergency Response Plan enters the activated mode of operations when the CNSC decides that an emergency response is necessary, and activates preparations for such a response.
- The recovery mode follows the activated mode, and consists of activities to restore a non-emergency state, such as the standby or normal modes.

Within the context of the CNSC Emergency Response Plan, a nuclear emergency is any abnormal situation associated with a radiological activity or a CNSC-licensed activity or facility that could require prompt action beyond normal procedures in order to limit damage to persons, property or the environment.

These nuclear emergencies could be off-site or on-site emergencies. For example, a nuclear emergency could be created by events related to the following situations:

- the release, or potential release, of radioactive contaminants from a Canadian or foreign nuclear power plant (NPP);
- any other CNSC-licensed facility or activity;
- any nuclear substance prescribed in the NSCA; or
- the loss, theft, discovery or transport of nuclear substances within or outside of Canada

The nature of the above involvement could range from exchanging ideas and information to coordinating plans, attending training programs, participating in exercises, and responding to actual emergencies. The CNSC Emergency Response Plan provides corporate guidelines for employee involvement.

CNSC staff members in this emergency organization are defined in the plan depending upon the nature of the emergency. CNSC staff responsibilities in the event of a nuclear emergency parallel their responsibilities during routine CNSC operations.

As part of the CNSC's emergency response plan, the CNSC has established various technical and administrative arrangements. They include bilateral cooperation agreements with other national and international jurisdictions, as well as operation of a CNSC Duty Officer Program whereby anyone can seek emergency information, advice, or assistance 24 hours a day for actual or potential incidents involving nuclear materials or radiation.

Annex 17 (ii) a: Environmental Assessment Process

Environmental Assessments (EAs) are initiated following an application under the *Nuclear Safety and Control Act* (NSCA) for a licence to prepare an NPP site, and are carried out under the *Canadian Environmental Assessment Act* (CEAA). EAs identify whether a specific project is likely to cause significant environmental effects, and ensure that potentially significant adverse effects are identified and mitigated to the extent possible. By considering environmental effects and mitigation early in project planning, potential delays and unnecessary costs can be avoided or reduced. The CNSC is required to carry out an EA when federal approval (as indicated in the CEAA Law List Regulations) is needed for the proposed project.

In the context of licensing a new NPP, this means that before any licensing decision can be made with respect to the new NPP, an EA must be completed with a decision that the project is not likely to cause significant adverse environmental effects with the available mitigation measures. If the decision on the EA is negative, the project will not proceed to licensing, pursuant to the NSCA.

Life extension projects for existing NPPs fall under the screening EA process. A screening is a type of EA established under the CEAA that documents the environmental effects of a proposed project and determines the need to eliminate or mitigate likely significant adverse environmental effects. The CNSC refers to screening EA results to decide whether the project has potential to cause adverse environmental effects. Regulatory approvals and licensing decisions under the NSCA regarding the life extension project can be rendered if a decision is made that significant adverse environmental effects are not likely after taking into account the implementation of any mitigating measures. As the responsible authority, the CNSC determines the scope of the screening EA. Documentation generated during the screening EA includes the CNSC's *EA* Guidelines, the EA Study Report (preparation of which is generally delegated to the licensee), and the EA Screening Report, which is prepared by the CNSC.

Examples of results from an EA Screening Reports for life extension projects of existing NPPs are provided in Article 17, subsection 17 (iii) b.

A proposal to construct a new nuclear power reactor generating more that 25 MW (thermal) is subject to a comprehensive study-level EA, in accordance with the CEAA's *Comprehensive Study List Regulations*. This type of EA requires mandatory opportunities for public participation.

It should be noted that projects undergoing either a screening or a comprehensive study EA could be referred to a mediator or a review-panel EA based on a request from the Commission to the Minister of the Environment or directly by the Minister of the Environment when:

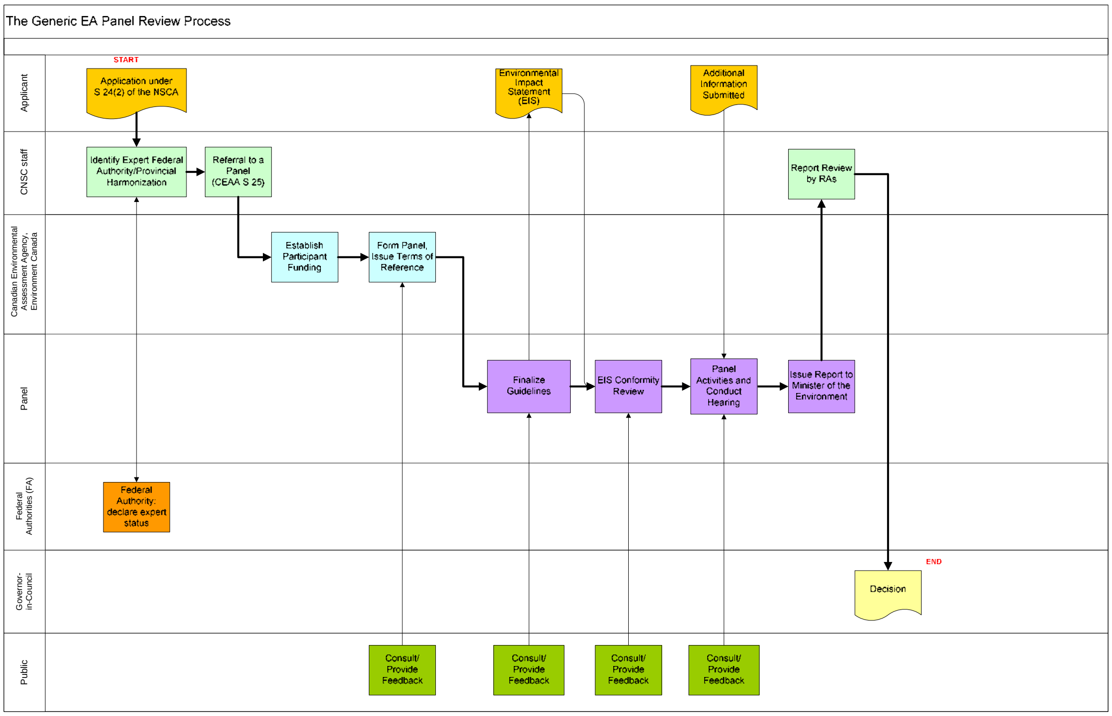
- it may cause significant adverse environmental effects, after taking into account mitigation measures;
- it is uncertain whether a project will cause significant environmental effects, given the implementation of mitigation measures; or
- public concerns warrant such referral.

If a decision is made to refer the EA for a new NPP for review by an EA panel, the CEAA provides for one of the following three approaches to be taken for establishment of the panel:

- a Canadian Environmental Assessment Agency-only panel review panel, whereby the EA is conducted by a panel appointed by the Minister of the Environment, in consultation with the responsible authority (Commission);
- a substitution arrangement whereby the NSCA Commission process is used as a complete substitute for an EA environmental assessment review-panel review; or

- a joint CNSC-Canadian Environmental Assessment Agency process, whereby the Commission (represented by one or more members) is supplemented with temporary member(s) appointed by the Minister of the Environment, in consultation with the responsible authority (the Commission). A joint review process could also include an additional jurisdiction where appropriate (for example, the province).

The following figure provides a graphic representation of the generic EA panel review process.



The decision by the Minister of the Environment is based on discussions between the CNSC as the primary responsible authority for the EA, other identified responsible authorities, the Canadian Environmental Assessment Agency, and other federal departments and agencies having an interest in the project. The procedures for the conduct of the panel review would depend on the approach selected, but would incorporate, as appropriate, the procedures set out in the 1997 Ministerial Guidelines entitled *Procedures for an Assessment by a Review Panel* available at http://www.ceaa-acee.gc.ca/013/0001/0007/panelpro_e.htm.

A panel review involves these key documents:

- Terms of Reference of the panel: issued by the Minister of the Environment, following consultation with the responsible authorities;
- Environmental Impact Study (EIS) Guidelines: developed by federal departments and agencies or the panel, usually after public consultation, and issued to the licence applicant;
- EIS report: prepared by the licence applicant, in response to the requirements of the EIS Guidelines;
- Report of the Review Panel: prepared by the panel following public hearings, submitted to the Minister of the Environment, and made available to the public; and
- Government Response to Recommendations of the Review Panel: prepared by the responsible authority, in consultation with other federal departments, and submitted for approval by the Governor in Council, before being released to the proponent and the public.

When a project is subject to an EA by several jurisdictions there may be a need to harmonize the federal EA process with provincial EA requirements to coordinate EA activities where possible,. Given the potential for such situations, the federal Minister of the Environment has entered into EA cooperation agreements with other Canadian jurisdictions. These agreements provide guidelines for the roles and responsibilities of each level of government in the assessment of such projects. These agreements also contain provisions allowing jurisdictions that have no EA responsibilities but that have an interest in the project, to participate in the EA process (for example, aboriginal groups).

Annex 19 (vii): Programs to Collect and Analyse Information on Operating Experience

Programs to collect and analyse information on operating experience (OPEX) are established, the results obtained, and the conclusions drawn are acted upon. Existing mechanisms are used to share important experience among the CANDU industry and with international bodies and other operating organizations and regulatory bodies.

Operating Experience Feedback Systems

The process of collecting, analysing, and disseminating lessons learned from information arising from the OPEX is known as a feedback process or system. Feedback systems established by the licensees in Canada are normally part of the licensees' QA program. The licensees' OPEX feedback systems also involve the CNSC, CANDU Owners' Group (COG), AECL and other organisations.

Requirements and Obligations

Clause 3.9 of the CSA standard *Operations Quality Assurance for Nuclear Power Plants* (CSA-N286.5) calls for measures to make sure that operations experience is documented, assessed and incorporated into the operation of the NPP and/or its QA programs as appropriate. It also calls for making this information available to personnel in the other phases of the NPP's life cycle. Under this clause, the CNSC has been conducting inspections in NPPs and licensee's corporate offices to make sure that the existing feedback systems achieve their objectives.

There are also international obligations that have to be met by the CNSC. As a member in the IAEA and the Organization for Economic Cooperation and Development (OECD), Canada is committed to report to the Incident Reporting Systems (IRS) operated by both the IAEA and the Nuclear Energy Agency (NEA) of the OECD on significant events that occur in Canadian NPPs. As a participant, Canada appointed a member of the CNSC staff as a national coordinator to collect and analyse information on events occurring in Canada, and to transmit them to the IAEA.

Sources of Information

Station condition records or event reports that are written by the licensees are the primary source of information. They provide information on undesirable events that are considered significant in the operation of nuclear generating units and related facilities.

Other licensee reports include the licensees' quarterly reports, in-service reports and internal audit reports. On the regulatory side, the CNSC issues inspection reports on NPP operations in nuclear power stations. These reports contain the CNSC inspection teams' findings and the deficiencies that the licensees are required to correct.

International sources include the IRS and International Nuclear Event Scale (INES) reports from the IAEA. The CNSC provides internet access to these reports to all Canadian NPP licensees.

Channels of Feedback

The licensees have developed feedback systems to integrate OPEX into all aspects of NPP operation and management. For example, NBPN has developed the Problem Identification and Corrective Action system, while OPG has an OPEX site that incorporates SCRs and operating experience from the World Association of Nuclear Operators WANO, Institute of Nuclear Power Operators and COG sites. Similar systems exist at other Canadian NPPs. AECL has implemented a similar system for its research reactor facilities at Chalk River.

The COG program involves exchange of information on OPEX between CANDU NPPs. Canadian COG members hold weekly OPEX screening meetings via teleconference and provide the results to other COG members to determine if they are susceptible to a similar occurrence.

CANDU owners also share safety and regulatory issues via the regularly scheduled Regulatory Feedback Team meeting for CANDU NPP owners, chaired by AECL. The purpose of this feedback forum is to ensure that design, analysis and operating experience is communicated to all CANDU operators and that emerging issues are fed into new CANDU designs. This forum also provides transfer of key information to the CANDU utilities through station information bulletins and advisory notices.

CNSC staff maintains a database to collect, screen, store and retrieve operational data. It includes records of events reported by the licensees in accordance with CNSC regulatory standard S-99. CNSC staff review and trend these events to aid in the regulatory oversight of the NPP.