DECOMMISSIONING OF NUCLEAR FACILITIES IN CANADA

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ABSTRACT

The Canadian Nuclear Safety Commission (CNSC) protects the health, safety and security of Canadians as well as the environment, and respects Canada's international commitments on the peaceful use of nuclear energy. It was established in 2000 under the *Nuclear Safety and Control Act* (NSCA), and was created to replace the former Atomic Energy Control Board (AECB), which was founded in 1946.

The CNSC operates and enforces regulations under the NSCA. Nuclear activities are carefully regulated to ensure their safe operation. The NSCA prohibits any person from preparing a site construction, operating, decommissioning or abandoning a nuclear facility without first obtaining a licence granted by the CNSC. Under the NSCA, specific requirements for decommissioning planning are set out in the following regulations:

- Uranium Mines and Mills;
- Class I Nuclear Facilities;
- Class II Nuclear Facilities.

This paper will discuss the CNSC and the decommissioning work in Canada. It will provide the CNSC's regulatory framework, licensing process, requirements for decommissioning plans, considerations for decommissioning and examples of decommissioning projects in Canada and some of the lessons learned.

1. INTRODUCTION

1.1 The Canadian Nuclear Safety Commission

The Canadian Nuclear Safety Commission (CNSC) regulates the use of nuclear energy and materials to protect the health, safety and security of Canadians and the environment; and to implement Canada's international commitments on the peaceful use of nuclear energy.

CNSC was established in 2000 under the *Nuclear Safety and Control Act* (NSCA) and reports to Parliament through the Minister of Natural Resources. CNSC was created to replace the former Atomic Energy Control Board (AECB), which was founded in 1946.

Under the NSCA, CNSC's mandate involves four major areas:

- regulation of the development, production and use of nuclear energy in Canada to protect health, safety and the environment;
- regulation of the production, possession, use and transport of nuclear substances, and the production, possession and use of prescribed equipment and prescribed information;
- implementation of measures respecting international control of the development, production, transport and use of nuclear energy and substances, including measures respecting the non-proliferation of nuclear weapons and nuclear explosive devices;
- dissemination of scientific, technical and regulatory information concerning the activities of CNSC, and the effects on the environment, on the health and safety of persons, of the development, production, possession, transport and use of nuclear substances.

1.2 CNSC Licensing Process

The CNSC operates and enforces regulations under the NSCA. Nuclear activities are carefully regulated to ensure their safe operation. Part of the CNSC regulatory control is in the licensing process. The stages of the licensing process are as follows:

- Site Preparation
- Site Construction
- Site Operation
- Decommissioning
- Abandonment

For each stage of licensing, there is a requirement for a license, and in some cases, an environmental assessment that examines the lifecycle of a nuclear activity. The NSCA prohibits any person from preparing a site construction, operating, decommissioning or abandoning a nuclear facility without first obtaining a licence granted by the CNSC.

The nuclear industry is subject to federal jurisdiction through the NSCA. However, the CNSC would also expect that a nuclear facility comply with applicable provincial regulations. Consequently, the CNSC has established a joint regulatory process. This means that the CNSC, as a lead agency, invites other regulatory agencies, federal and provincial, who may have an interest in the operations of the nuclear facility to provide input to the CNSC on the facility's operations.

2.0 DECOMMISSIONING

2.1 Regulatory Requirements

Under the NSCA, specific requirements for decommissioning planning are set out in the following regulations:

- Uranium Mines and Mills;
- Class I Nuclear Facilities;
- Class II Nuclear Facilities.

CNSC's Regulatory Guide G-219 *Decommissioning Planning for Licensed Activities* [1], provides guidance regarding the preparation of decommissioning plans for activities for which it licenses. The guide presents information of interest to those who have incurred, or expect to incur, obligations with respect to the decommissioning of activities licensed by the CNSC.

In accordance with G-219, the CNSC requires that Class I facilities and uranium mines and mills licensees keep decommissioning plans up to date throughout the lifecycle of a licensed activity. The CNSC also requires that licensees prepare a preliminary decommissioning plan and detailed decommissioning plan for approval.

The applicable regulations and Regulatory Guide can be viewed on the CNSC Web site at: www.nuclearsafety.gc.ca

In addition to G-219, the CNSC has recently included the Canadian Standards Association (CSA) standard CSA N294 *Decommissioning of nuclear facilities* [2] as a reference in its licensing documents. This standard complements the requirements for conducting nuclear activities in the Canadian context.

2.2 Preliminary Decommissioning Plan

The preliminary decommissioning plan (PDP) must be filed with the CNSC as early as possible in the lifecycle of the activity or facility. In the case of nuclear facilities, specific requirements for decommissioning planning are set out in the CNSC regulations for uranium mines and mills, and Class I and Class II nuclear facilities [1].

The preliminary plan documents the preferred decommissioning strategy and objectives at the end of decommissioning. The plan should be sufficiently detailed to assure that the proposed approach is technically and financially feasible. It must also be in the interests of health, safety, security and protection of the environment. The plan defines areas to be decommissioned and the general structure and sequence of the principal decommissioning work packages envisioned [1].

2.3 Detailed Decommissioning Plan

The detailed decommissioning plan (DDP) is filed with the regulatory body for appropriate licensing action prior to beginning decommissioning activities. The detailed plan normally defines and adds procedural and organizational details to the preliminary plan. The detailed plan serves as a guide for the decommissioning of a licensed activity or facility. Once the CNSC approves the detailed plan, it will be incorporated into the licence authorizing the decommissioning [1].

3.0 DECOMMISSIONING ACTIVITIES IN CANADA

3.1 Completed

Over the years, the CNSC or its predecessor agency, the AECB, has provided regulatory oversight for a number of decommissioned nuclear facilities including:

- Tunney's Pasture Isotope Processing Facility;
- Bruce Heavy Water Plant;
- University of Toronto SLOWPOKE-2 Reactor Facility;
- Beaverlodge Inactive Uranium Tailings Site.

The following sections provide a brief description of the decommissioned facilities.

3.1.1 Tunney's Pasture Isotope Processing Facility

The Tunney's Pasture Isotope Processing Facility was located in Ottawa, Ontario. The facility was decommissioned in two phases, first with the removal of the hot cells then removal of the ventilation. The site was released for unrestricted use in 1993.

3.1.2 Bruce Heavy Water Plant

The Bruce Heavy Water Plant (BHWP) was a Class 1B nuclear facility contained within the boundaries of the Bruce nuclear site located in Tiverton, Ontario. It began producing heavy water in 1973 and continued until the last production facilities were shutdown in 1998. Decommissioning of some of the older production systems began in 1993.

The demolition of the BHWP was completed in 2006 and all contaminated soil has been remediated. The project is in a 3-year period of end-state environmental monitoring, which ends in 2014, prior to applying for a Licence to Abandon [3].

3.1.3 University of Toronto SLOWPOKE-2 Reactor Facility

In 2000, the CNSC issued a Decommissioning Licence to the University of Toronto, located in Toronto, Ontario, to allow for the decommissioning of the SLOWPOKE-2 Reactor Facility. The reactor measured 2.5 meters in diameter and 5.9 meters deep. In the same year, the reactor was decommissioned and decontaminated to levels permitting unrestricted use.

3.1.4 Beaverlodge Inactive Uranium Tailings Site

The Beaverlodge site was a uranium mine located near Uranium City in the northwest corner of Saskatchewan. Mining of ore at his site began in 1950 and milling in 1953, with both activities continuing until closure in 1982. Decommissioning began in 1982 and was completed in 1985. Since then, the site has been in a monitoring and maintenance phase. All mine structures have been removed from the site, all but one of the open pits has been completely backfilled, and mine shafts have been capped and decommissioned.

All of the control structures associated with this site is passive. Three small water-level control structures exist but no effluent treatment plants. There are roads, waste rock piles and tailings management areas that are subject to inspection programs and local and area-wide environmental monitoring programs.

The Beaverlodge site has three tailings management areas and approximately 5.1 million tonnes of waste rock on the site. The site consists of 73 separate properties that cover approximately 744 hectares [3].

3.2 Recent and Ongoing

Recent and ongoing decommissioning facilities that are currently under CNSC regulatory oversight include:

- Whiteshell Laboratories;
- Cluff Lake;
- Dalhousie University SLOWPOKE-2 Reactor Facility.

These facilities are described in the following sections.

3.2.1 Whiteshell Laboratories

The Whiteshell Laboratories (WL) facility was established by the Atomic Energy Canada Limited (AECL) at Pinawa, Manitoba in the early 1960s to carry out nuclear research and development activities for higher-temperature versions of the [1]CANDU® reactor. In 1997, AECL decided to discontinue research programs and operations at the facility, and the Canadian federal government concurred with the decision in 1998. In 1999, AECL began to prepare plans for the safe and effective decommissioning of WL.

The major structures located on the WL site include a WR-1 reactor, the shielded facilities, research laboratories, and liquid and solid radioactive waste management areas, including the Concrete Canister Storage Facility (CCSF) for the dry storage of research reactor fuel.

WL is currently licensed under its second Nuclear Research and Test Establishment Decommissioning License that is effective from January 1, 2009 until December 31, 2018. This licence authorizes AECL to undertake decommissioning activities and residual operations at WL and to construct and operate two new storage buildings for low-level waste (LLW) resulting from the decommissioning and operations.

The focus of the decommissioning activities is on decontamination and modifications of nuclear activities include preparing for and undertaking demolition of the principal radioisotope laboratory building, advancing the plans for the standpipe remediation, and re-establishing the functions of the existing site liquid-waste treatment, active laundry and decontamination facilities into updated facilities, followed by the decommissioning of their existing buildings. Also included is the design and construction of associated enabling facilities, including a waste clearance facility, a waste handling facility, remediation and expansion of waste storage facilities, site infrastructure service systems reconfiguration, and the demolition of redundant non-nuclear service buildings. Activities planned for subsequent licensing periods include the final decommissioning of the WR-1 reactor, waste management area (WMA) storage structures, the shielded facilities and the enabling facilities.

[1] "CANDU® is a registered trade mark of Atomic Energy of Canada Limited."

The WR-1 reactor at WL is permanently shutdown, de-fuelled and partially decommissioned. The facility continues to be monitored and maintained by AECL staff but decommissioning of the reactor to its final end-state is planned to start in the 2024 to 2026 timeframe.

The Van de Graff Accelerator and the Neutron Generator have been fully decommissioned. CNSC accepted the end-state reports and confirmed that the radiological end-state requirements for the facilities have been met [3].

3.2.2 Cluff Lake

The Cluff Lake Project, which is owned and operated by AREVA, began in 1981 and was completed at the end of 2002, when ore reserves were depleted. More than 62 million pounds of U3O8 was produced over the 22-year life of the project. Site facilities included the mill and tailings management area (TMA), four open-pit and two underground mines, the camp for workers and site infrastructure. Cluff Lake was the first of the northern Saskatchewan uranium mines to move into decommissioning. The decommissioning licence was received from the CNSC in July 2004, and followed five years of public consultation, environmental assessment and regulatory review, and marked the completion of the planning phase of work to return the site to a natural state. The objective is to return the site as closely as practical to its original state in a manner that both protects the environment and allows traditional uses such as fishing, trapping and hunting to be carried out safely.

Site staff and contractors carried out decommissioning work between 2004 and 2006, with re-vegetation of restored areas carrying into 2007. An extensive follow-up monitoring program to assess the performance of the decommissioned site is now underway. A small number of staff remains on site to carry out the monitoring program and provide minor maintenance at restored areas. Ultimately, when all stakeholders judge the performance of the decommissioned site satisfactory, it is expected that the site will be transferred to the Province of Saskatchewan [3].

3.2.3 Dalhousie University SLOWPOKE-2 Reactor Facility

Dalhousie University's SLOWPOKE-2 Reactor (DUSR) facility, located in Halifax, Nova Scotia, was part of Dalhousie's Trace Analysis Research Centre. In November 2004, the CNSC received a notice from Dalhousie University of its intent to de-fuel and decommission the DUSR facility. At that time, Dalhousie University had provided a brief outline of the project to initiate the environmental assessment (EA) process. The EA process was subsequently put on hold at the request of Dalhousie University (the proponent) in May 2006. In July 2008, Dalhousie University notified the CNSC of its intention to proceed with decommissioning and CNSC re-started the EA process.

The CNSC held a public hearing in March 2009 and approved the Proposed EA Guidelines for the Proposed Decommissioning of the SLOWPOKE-2 Reactor Facility. In January 2011, a hearing was held for Dalhousie University's application to the CNSC for the issuance of a Decommissioning Licence, which was granted and is currently valid from January 14, 2011 to December 31, 2015 and concurrently the Commission revoked of the current Non-power Operating Licence for the Dalhousie University SLOWPOKE-2 Reactor Facility.

DUSR hired AECL as the sole contractor to conduct the decommissioning activities of the DUSR facility. The AECL activities on the DUSR-Decommissioning Project are executed under AECL CANDU® services, within the CANDU® Reactor Division. As of March 31, 2010 the following decommissioning activities occurred:

- preparation of the rooms in the building where the reactor is located, by removal of all items not required for the defueling and decommissioning process;
- preliminary surveys to identify areas with potential radioactive contamination;
- defueling of the reactor and disposal of the fuel;
- dismantling of the reactor components and identifying radioactive, contaminated, hazardous, and clean components;
- packaging and transportation of all radioactive, contaminated, hazardous, and clean components;
- packaging and transportation of all radioactive components for authorized disposal or storage;
- disposal of other radioactive and non-radioactive wastes;
- decontamination of the site to render it free of residual radioactive contamination.

These decommissioning activities were verified by CNSC staff during a compliance inspection during the month of March 2011. Currently, CNSC staff is awaiting submission of the end-state report prior to proceeding with a licensing hearing for the issuance of a licence to abandon. It is currently expected that the hearing will take place during the summer of 2011.

3.3 Future

Additional decommissioning activities is expected in Canada over the next several decades due to a number of nuclear facilities approaching their end of operational life and other facilities reaching the end of their planned storage with surveillance period.

3.3.1 Pickering Nuclear Generating Station-A

Pickering Nuclear Generating Station (NGS)-A, the first four of the Pickering reactors, went into service in 1971 to produce 500 megawatts of electricity each and continued to operate safely until 1997. Of these reactors, units 1 and 4 have returned to commercial operation while units 2 and 3 are in an approved shutdown state. Pickering Nuclear Generating Station-A is expected to be shutdown in 2021 [3].

3.3.2 AECL Off-site Prototype Power Reactors

AECL owns three prototype power reactors that are located outside of Chalk River and Whiteshell Laboratories: Douglas Point in Tiverton, Ontario; Gentilly-1 in Bécancour, Québec; and Nuclear Power Demonstration in Rolphton, Ontario.

These facilities ceased operating in the 1980's. After the facilities shutdown, AECL implemented a three-phase approach to decommissioning. The first phase is to place each facility into a safe state of storage. The second phase is storage with surveillance to allow for radioactive decay and the third phase allows for final dismantlement.

AECL has successfully put all facilities into a safe state of storage with surveillance and is planning to keep these facilities in this state for the next 50 to 100 years. Final decommissioning of the shutdown prototype reactor sites is expected to occur between 2030 and 2070.

3.4 Consideration for Updating Regulatory Requirements in the Future

The growth of decommissioning activities along with the knowledge gained from these activities will require the CNSC to revisit the current regulatory framework on decommissioning.

Since the publication of Regulatory Guides G-219 *Decommissioning Planning for Licensed Activities* and G-206 *Financial Guarantees for the Decommissioning of Licensed Activities*, both guides have been referenced in licences and the associated documents. As indicated from the titles, G-219 provides guidance on the preparation of decommissioning plans [1], and G-206 provides guidance regarding the establishment and maintenance of measures to fund the decommissioning activities licensed by the CNSC [4]; both documents were published in 2000. With the decommissioning experience gained since 2000 and with changing international and best practices, the requirements have evolved and become better defined. Subsequently, the regulatory documents need to be revisited to determine if they need to be updated, replaced or withdrawn.

The issuance of CSA N294 has an impact on the fate of the guides. Since CSA N294 came available in 2009, CNSC staff have used the standard, referenced it in licensing documents, and CNSC staff have referred N294 to licensees for the development of DDPs and the development of PDPs for new builds.

The options for G-219 and G-206 include:

- update G-219 to reflect current international and best practices;
- update G-206 to reflect current international and best practices;
- combine G-219 and G-206 as one document and update it to reflect current international and best practices;
- replace G-219 with CSA 294 in incidences where G-219 is referenced.

Regardless of which option is chosen, both G-219 and CSA N294 will need to be updated to address topics that have recently surfaced from discussions on decommissioning multi-unit stations, such as the Pickering NGS-A:

- requirements for decommissioning of multi-unit stations;
- when to submit a detailed decommissioning plan to the regulatory body;
- requirements for a storage with surveillance monitoring program.

4.0 CONSIDERATIONS FOR DECOMMISSIONING AND LESSONS LEARNED

4.1 Technical

Experience gained from the facilities described above and other decommissioning activities indicate that there are a number of technical decommissioning considerations to take into account. Considerations include the principles of reuse, reduce, and recycle, and that occupational health and safety is sometimes the most important aspect of a decommissioning project. Another key issue is the disposal of waste associated with decommissioning, including characterization, decontamination and the lack of disposal options.

Related to the considerations above is the decommissioning strategy, which may be facility specific. Whether a facility undertakes prompt decommissioning, deferred decommissioning, or a combination, there are advantages and disadvantages of each strategy.

Prompt dismantling reduces the risk of losing knowledgeable and experienced staff and documentation, and change in regulatory requirements. On the other hand, the risks associated with this strategy include the potential for worker exposure to high radiological doses and the lack of available waste management facilities and disposal capacities.

With the delay and decay of the radiological materials, deferred removal reduces the risk of worker exposure to high radiological doses. Another advantage with this strategy is the increased probability of available radiological waste disposal sites. However, there are also disadvantages of deferred dismantlement, including the loss of knowledgeable and experienced staff and records.

Regardless of the decommissioning strategy, potential revenues, costs and available funding, and other economical considerations should be taken into account. The financial guarantee associated with decommissioning is further discussed in the paper *Implementation of a Financial Guarantee Policy at the CNSC*, which will also be presented at the 2011 CNS conference on Waste Management, Decommissioning and Environmental Restoration for Canada's Nuclear Activities.

4.2 Stakeholder Engagement

During the decommissioning planning process, consideration also has to be made to address stakeholder concerns. This can be done with additional environmental assessments, environmental follow-up monitoring programs, or both. Also, the licensee can address public and other stakeholder concerns in a public information program that is part of the decommissioning plan and through hosting open-houses within the community.

Consideration also needs to be made for consultation and accommodation with Canada's Aboriginal peoples. The CNSC strives to meet its commitment to excellence, in part, through a good governance approach to effective and well-managed Aboriginal consultation processes when Aboriginal rights or interests could be impacted. The CNSC recognizes that the effect of good faith consultation may result in the need to establish accommodation measures to prevent or minimize impacts of activities involving nuclear substances on Aboriginal Interests.

5.0 SUMMARY

As aging nuclear facilities reach the end of their operational life and new nuclear power plants could be planned for construction, there will be a surge in decommissioning activities, including planning for decommissioning. With the growth of decommissioning and the introduction of new scenarios, e.g., criteria for a storage with surveillance monitoring program, the CNSC will update its regulatory requirements to meet international and best practices.

Based on the decommissioning experience to date, regardless of the facility type or the size, decommissioning shall provide for the following:

- protection of health and safety of workers and public;
- protection of the environment;
- compliance with regulatory requirements;
- keeping radiation exposures as low as reasonably achievable (ALARA);

- management of all radioactive and hazardous materials generated;
- security;
- safeguards.

These provisions are consistent with the CNSC's mandate and the requirements of the NSCA.

REFERENCES

[1] CNSC Regulatory Guide G-219 *Decommissioning Planning for Licensed Activities*, 2000. http://www.nuclearsafety.gc.ca/pubs_catalogue/uploads/G219_e.pdf

[2] CSA N294 *Decommissioning of facilities containing nuclear substances*, 2009.

[3] *Canada's Third National Report for the Joint Convention*, 2008. http://www.nuclearsafety.gc.ca/eng/readingroom/reports/jointconvention/

[4] CNSC Regulatory Guide G-206 *Financial Guarantees for the Decommissioning of Licensed Activities*, 2000. http://www.nuclearsafety.gc.ca/pubs_catalogue/uploads/G206_e.pdf