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Developments in the EPRI Decommissioning Technology Program

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ABSTRACT

This paper presents an overview of the EPRI program to assist nuclear power plant operators in their efforts to minimize the cost and risks of decommissioning through enhanced planning, applying lessons learned by other utilities with retired plants, and the use of advanced technology. Guidance is developed on unresolved issues in low-level waste management, site characterization, radiation dose modeling for site release, and license termination plans. Capturing the lessons learned from current decommissioning work at power plants in the United States and archiving for future use includes the preparation of guidance documents on license termination issues.

I. INTRODUCTION

EPRI has been involved in the decommissioning of nuclear power plants ever since the first large U.S. power plants started decommissioning activities in the mid-1990s. Until 15 years ago, utility plant closures had been limited to small plants, such as Humboldt Bay, LaCrosse and Peach Bottom 1 HTGR. With the exception of Pathfinder and Saxton, these plants were placed in safestore mode, with only limited demolition activities. Also, some larger plants of earlier design had ceased operation, including Fermi 1 LMR, Dresden 1 BWR and Indian Point 1 PWR. However, decommissioning work was limited at those plants, as they were on multi-unit sites with large modern units.

With the exception of Three Mile Island Unit 2 which suffered an accident in 1979, the first large plants to cease operation were Trojan PWR (1100MWe) and Rancho Seco PWR (900MWe). These plants were shut down as a result of economic issues and public vote, respectively. In the 1990's several other plants closed, primarily for economic reasons. These included Big Rock Point BWR, San Onofre 1, Yankee Rowe, Maine Yankee, Connecticut Yankee PWRs. Two atypical closures in this period were Fort St. Vrain HTGR and Shoreham BWR (which never saw full power operation).

The most recent plants to cease operation were Zion PWRs and Millstone 1 BWR. In both cases, regulatory issues had had a serious impact on the utility's nuclear plant operations, and the least economic plant was closed during that period. Since then, the economic viability of nuclear power plants has improved in a major way, and the emphasis has changed from plant closure to license renewal. Barring unforeseen problems, no further plant closures are anticipated in the next few years.

Details of the status of plants currently being decommissioned in the United States are provided in Table 1. In addition to utilities in the United States, organizations in Britain, France, Italy, Japan, Spain and Taiwan are involved in the EPRI program. Although Ontario Power Generation and the CANDU Owners Group are members of the EPRI Nuclear Sector Program, there has been little Canadian involvement to date in the decommissioning technology program.

The original objective of the EPRI program was to capture the experiences of the first major decommissioning activities, and to provide technical assistance to the electric utilities starting down that course of action. In several cases, the closure had been premature and unanticipated, and the delays in moving to decommissioning status caused considerable extra expense. Later, the EPRI program added the objectives of demonstrating advanced technology and providing technical support for industry initiatives on regulatory issues, led by Nuclear Energy Institute, and assisting power plants evaluate technologies developed in the large program of the US Department of Energy. Figure 1 depicts the interactions with other organizations. The most recent phase of the EPRI program focuses on license termination issues and archiving the best practices for use in the distant future when some of the currently operating plants in the United States close down.

In the future, the decommissioning circle will be completed with these results being made available to the operating plants – a direct benefit of the technology developed under the decommissioning program. With the uncertain availability of low level waste disposal sites in the longer term, these results and techniques may well become important contributors to future economic operation.

The EPRI program assists nuclear plant operators in their efforts to minimize the cost and risks of decommissioning through enhanced planning, applying lessons learned by other utilities with retired plants, and the use of advanced technology. Guidance is developed on unresolved issues in low-level waste management, site characterization, radiation dose modeling for site release, and license termination plans. Anticipating and addressing the needs of utilities facing premature (unplanned) shutdown of nuclear units in the future is an important goal. Capturing the lessons learned from current decommissioning work at power plants and archiving for future use includes the preparation of guidance documents on license termination issues. Figure 2 shows key elements of the program, within the overall goal of reducing the risks and costs of decommissioning nuclear power plants.

EPRI work emphasizes technology developments, as distinct from regulatory and licensing issues, which continue to be the responsibility of NEI. However, EPRI is participating in a number of joint projects by providing technical support to NEI to address regulatory issues in decommissioning, including license termination, material recycle, and site release. The following sections describe examples of key products of the program.

II. PLANNING FOR DECOMMISSIONING

Utility experiences in recent years show that significant cost savings will result from advance planning for the eventual closure of nuclear power plants. EPRI has developed a manual that provides a framework for planning ahead for plant decommissioning by drawing upon the experiences of utilities currently involved in decommissioning. It identifies important advance planning decisions, tasks, and contributing disciplines, establishes activity precedence relationships and defines data requirements. The manual also describes actions that utilities can take prior to plant shutdown to ease the transition to decommissioning status.

Effective planning is a key to cost control, a critical aspect of decommissioning. EPRI developed this manual to capture the pre-planning lessons learned from in-progress plant decommissioning projects. A decision framework was developed to cover the following specific tasks for use in pre-planning decommissioning:

- Identifying key decisions and tasks in the advance planning process
- Establishing ordered relationships and dependencies between the key decisions and tasks
- Identifying the key disciplines required to support the decision process and tasks
- Identifying data inputs to support the decision process and tasks

Sixty-five Decommissioning Activities were identified to support tactical level pre-planning, and consolidated them into thirty-two pre-planning tasks which define advance-planning requirements at the discipline level. These activities are consolidated into elements on a Precedence Diagram network that provides order to the decision processes. The precedence relationships identify the tasks by lead discipline:

- Management/Finance/Human
- Resources
- Licensing/Ops/Training/QA
- Engineering
- Environmental Management and Occupational Health and Safety

Lessons learned from current decommissioning efforts suggest that more advance planning is needed for both the radiological (site survey) and non-radiological (hazardous materials) aspects of decommissioning. This decision framework for decommissioning pre-planning provides the nuclear power plant operator with the opportunity to substantially lower both the cost and risk of the decommissioning process. Guidance for three time frames; premature shutdown, planned shutdown in three to five years and long-term operation (data collection and contingency planning), will aid utilities in preparing for eventual plant closure. Utility managers currently involved in decommissioning power plants offered considerable input and advice, enabling the project to capture the best practices of utilities in the decommissioning phase.

III. WASTE MANAGEMENT

A nuclear facility which is pursuing decommissioning is faced with a wide variety of waste types and waste management options. The various options for waste conditioning (volume reduction) and disposal have increased in number and cost complexity over the past decade. This has created a need for a computer program capable of analyzing both existing and alternative waste management costs and volumes to identify the optimum approach for disposition of each waste type. EPRI developed the Decommissioning Waste Manager computer program to meet this need. It analyzes decommissioning waste volumes, weights, labor, characterization, packaging, shipping, treatment, storage, disposal and related cost elements with the intent of quantifying the existing decommissioning waste management program for any given waste generator.

The Decommissioning Waste Manager computer program follows the successful implementation of EPRI's Solid, Liquid, and Mixed Waste Manager computer programs. Together, the four programs comprise EPRI's Waste Logic suite of computer programs. The various programs have been tested, demonstrated and/or installed at more than 50 commercial nuclear power stations and have served as catalysts for reducing industry-wide waste management costs by more than $60,000,000 annually. The decommissioning program has been used to identify significant cost savings at UKAEA's Dounreay facility in Scotland. It is now being expanded to a multi-site database format to accommodate large decommissioning waste management programs, such as the one at the Dounreay site.

Although most decommissioned plants on single-unit sites in USA are opting for rapid deconstruction, reactor pressure vessel (RPV) extended SAFSTOR options may be desirable for decommissioning plants with disposal and/or transportation limitations. Dose and cost savings also may be achieved by delaying some segmentation tasks until significant radionuclide decay has occurred. A recent evaluation of the impact of RPV SAFSTOR strategies for PWRs and BWRs concluded that RPV SAFSTOR may be a desirable option for decommissioning plants in certain circumstances, in particular for BWRs due to the radiological characteristics of their larger RPVs. In addition, EPRI has been updating its extensive set of guidelines for the interim on-site storage of low and intermediate level wastes. Recent reports have been published on the interim storage of Greater than Class C (GTCC) wastes, the optimization of waste containers for storage, and waste volume and segregation strategies for the interim storage of Class B and C wastes.

IV. TERMINATION OF NUCLEAR PLANT LICENSES

The Nuclear Regulatory Commission requires utilities to submit License Termination Plan (LTP) documents years prior to the site license termination. The new license termination regulations involve numerous complex regulatory guidance documents. This complexity has resulted in the majority of initial LTP submittals experiencing numerous setbacks or delays in the NRC approval process. EPRI developed guidance to assist those engaged in future preparation by offering a comprehensive, "User Friendly" report that addresses the radiological components of license termination. This guide captures the lessons learned by those utilities currently undergoing the license termination process. This experience, coupled with consolidation of the important aspects of available regulatory guidance, benefits the next generation of utilities considering decommissioning and termination of their NRC Part 50 licenses.

The guide specifically addresses regulatory requirements and guidance, site characterization, dose modeling, site remediation, and final status survey. The appendices provide examples of a sampling plan and a conceptual schedule for site characterization. This report serves as a technical reference addressing a wide range of issues pertaining to the radiological aspects of license termination.

V. TECHNOLOGY DEVELOPMENTS

Control of radiation exposure during demolition activities has been a significant challenge at several plants. The "EPRI DFD" (Decontamination for Decommissioning) Process was developed to address this issue. The purpose of this process is to achieve efficient removal of radioactivity with minimum waste from retired plant systems, thereby reducing radiation fields. The process uses dilute fluoroboric acid with controlled oxidation potential. By removing all the outer scale and a thin layer of base metal from the surfaces, contamination can in many cases be reduced below the levels required to allow clearance (free-release) or recycle to form new components for the nuclear industry. The residual radiation fields can be reduced by a large factor, which reduces the worker radiation exposure associated with decommissioning. Furthermore, this dose rate reduction improves the viability of early dismantlement following plant closure, as opposed to waiting for a prolonged period for radioactive decay to occur. The results obtained in early applications of the EPRI DFD process, described in a paper at Spectrum '98, [1] demonstrated the benefits of taking this approach.

The EPRI DFD process has been applied successfully by EPRI licensees to many different components, in addition to the primary coolant systems of Big Rock Point BWR and Maine Yankee PWR, including pumps and heat exchangers, and material from DOE facilities. A key aspect of the existing technology that required further development for new applications of the DFD process is the management of secondary waste. The process produces ion exchange resin as the final waste form and disposal of the resulting radioactive ion exchange resin is unpopular and expensive, and is therefore the main constraint limiting further applications.

This development of electrochemical ion exchange to work with the EPRI DFD Process (called “EPRI DFDX”) is described in another paper to this conference. This overall process enables the collection of radioactive contamination from a thin layer of the surface of components and systems and its conversion into metal powder for disposal, driven by electrical energy. The metal powder, consisting primarily of iron, nickel and cobalt (including cobalt-58 and cobalt-60 radioisotopes) is easily collected. No other wastes are generated, and thus the new development represents almost theoretical efficiency of decontamination.

VI. LESSONS LEARNED BY ORGANIZATIONS INVOLVED IN DECOMMISSIONING NUCLEAR PLANTS

The following is a list of good practices developed from a review of experiences in planning decommissioning work and in the development of license termination plans:

- Maintain good relationships with internal & external stakeholders: staff, local communities and government agencies
- Establish an employee retention plan: it is essential to keep key staff
- Baseline Historical Site Assessment and Site Characterization: sample to determine extent of radiological and hazardous material contamination for entire site
- Characterize low-level waste on-site: type, volume, weight, isotopic mix
- Identify and characterize mixed waste (hazardous/radioactive) on-site.
- Inspect and characterize spent fuel for damage.
- Prepare design documents for spent fuel disposal: dry storage facility and handling systems.
- Locate and characterize previous on-site disposals and “spills”, including on-site burial, exemptions under previous regulations

VII. CONCLUSIONS

The US industry is close to completing the successful demonstrations of decommissioning large nuclear power plants, showing that it is practical and economically feasible, with no risk to the public. Thinking back to the mid 1990s, public perception then was that it could not be done, and there was not enough money to do it anyway. Of course, challenges remain but, overall, progress has been impressive and exceeded expectations. The experience gained over the past several years will be valuable to organizations initiating new decommissioning projects in the future, and archiving the lessons learned remains a key goal of the EPRI program.

Table 1: Status of US Nuclear Power Plants currently being Decommissioned

- Yankee Rowe, 180MW PWR
  - 90% complete, RV, SGs removed, green field 2005
- Trojan, 1100MW PWR
  - 95% complete, RV and SGs removed, dry storage of fuel completed
  - license termination 2005 (repower site)
- Maine Yankee, 900MW PWR, ~90% complete
  - SGs removed, RV out 9/02, containment down, green field 2005
- Connecticut Yankee, 600MW PWR
  - SGs removed, RV out 9/02, moving fuel, green field 2007
- Big Rock Point, 65MW BWR
  - ~85% complete, RV removed, green field 2005
- Rancho Seco, 900MW PWR
  - ~60% complete, incremental decommissioning, fuel in dry store
  - Completion 2008-2012, repower site
- San Onofre 1, 450MW PWR
  - RV out, dry storage facility for 3 units planned

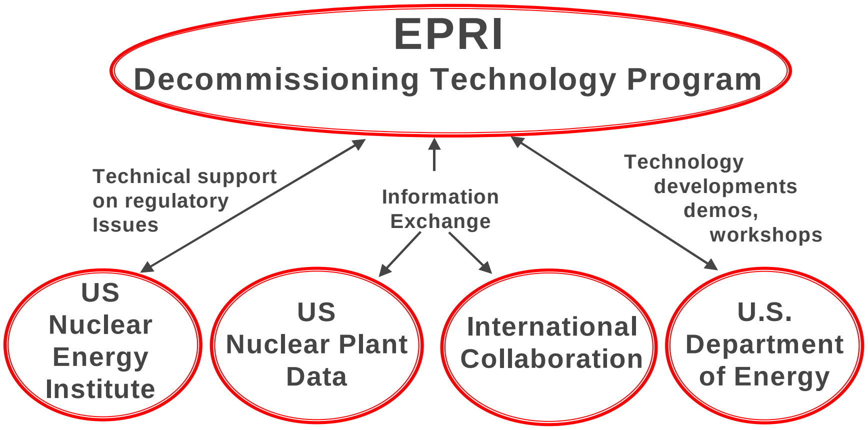

Figure 1: Interactions of the EPRI Decommissioning Technology Program

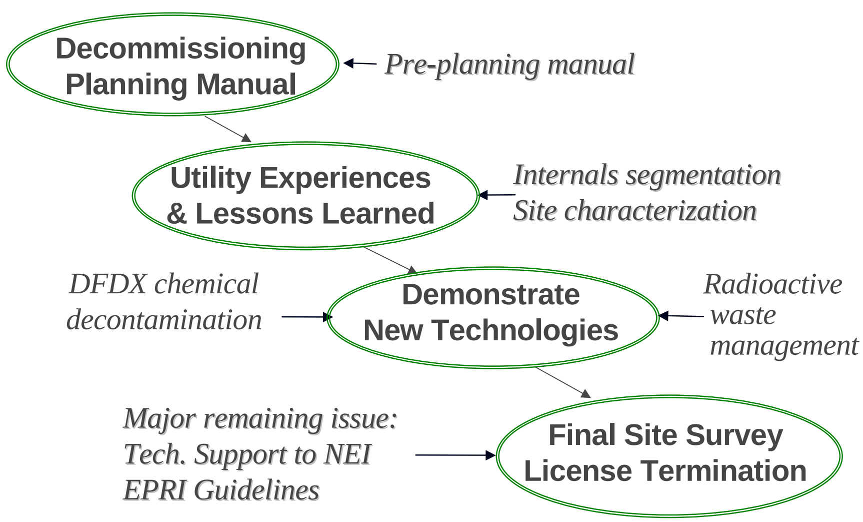

Figure 2: The EPRI Decommissioning Technology Program has the goal of reducing the risks and costs of decommissioning nuclear power plants