Conference on Lessons Learned from the Decommissioning of Nuclear Facilities and the Safe Termination of Nuclear Activities in 2006

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Decommissioning of Three U.S. Commercial Nuclear Power Plants

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Abstract

As President for the decommissioning of three large New England nuclear plants I have learned that maintaining a credible "safety-first" culture while managing to aggressive cost and schedule goals, developing a clear project plan and focus, developing a strong project team, maintain a strong focus on the management of risk and ensuring regulatory compliance are all critically vital to the success of a decommissioning project.

I have been President for the decommissioning of three commercial nuclear power plants in the northeast region of the United States. The nuclear power plant decommissioning experience in the US has been limited to small experimental reactors and research facilities and about eight commercial sized reactors. I participated in the initial planning for and the implementation of the decommissioning of Maine Yankee and was President and CEO for the completion of decommissioning for Connecticut Yankee and Yankee Rowe. These plants are briefly described below and key decommissioning statistics are provided in the following table.

Connecticut Yankee (CY), a 560 Megawatt Westinghouse PWR on the Connecticut River, began commercial operation in 1968 and was shut down for decommissioning in 1997. CY decommissioning was started in 1998 and will be completed next year. I took over as President of CY in 2003 and CEO in 2006

Maine Yankee (MY), an 860 Megawatt Combustion Engineering pressurized water reactor (PWR) nuclear power plant on the coast of Maine, began commercial operation in 1972 and was shutdown for decommissioning in 1997. MY decommissioning was started in 1998 and completed in 2005. I was Contract Manager for the start of Maine Yankee decommissioning Vice President of Decommissioning while we had fixed price contract for decommissioning prior to termination of the Contractor and became President when the Company decided to self-perform the decommissioning in 2001.

Yankee Rowe (YR), a 165 Megawatt Westinghouse PWR in western Massachusetts, began commercial operation in 1960 and was shut down for decommissioning in 1992. YR decommissioning was started in 1992 and will be completed next year. I became President in late 2005 and CEO in 2006 responsible for completing the physical work, terminating the NRC license and obtaining Site Closure.

Decommissioning Project Statistics

Plant	Length (Years)	Cost (million US $)	Project ORIR (Injuries/200,000 work hours)	Total Dose (Person-rem)
CY	9	850	1.27	860
MY	7	500	0.26	515
YR	15	750	1.96	594

All three projects were successful in that the work was accomplished safely, and the sites were (or are being) thoroughly cleaned up to meet the state and federal requirements. While the

decommissioning experience for each plant was somewhat unique, the processes for all three were basically the same. Prompt dismantlement was chosen to minimize the time and associated costs without sacrificing safety and worker dose.

As the decommissioning of the sites progressed, lessons were learned that helped to improve efficiency and thereby shorten schedule and cost. We learned in the course of these projects that effective planning by a strong management team, both early and throughout the process, was the most critical factor in reducing decommissioning time and project cost.

Decommissioning Planning: Begin Early with the End in Mind

Waste Management

When a plant shuts down for decommissioning the entire facility, including the components, becomes waste. Understanding waste streams and how they are handled and disposed is fundamental to planning how the decommissioning will be done. When starting the decommissioning of Maine Yankee waste disposal costs were high. This led us to embrace decontamination techniques such as surface scabbling to reduce waste volumes. As decommissioning progressed, we were able to negotiate waste disposal contracts with much lower costs. This change enabled us to employ a "Rip and Ship" approach. While it is true that waste volumes increased, there were substantial reductions in labor costs and time.

The approximate total waste quantities for three plants are listed below:

- Connecticut Yankee: 350 million pounds
- Maine Yankee: 460 million pounds
- Yankee Rowe: 170 million pounds

Despite best efforts at estimating waste quantities at the beginning of the projects, the waste quantities increased as we remediated areas and generated more soil waste than expected. While above grade structures can be more readily estimated, it is the below grade remediation that is most uncertain, even with today's characterization capabilities. Land area characterization data were utilized to estimate waste volumes. However, spread of contamination in soil is unpredictable due to a variety of factors including inconsistencies in soil/groundwater conductivity, bedrock surface features, and structural impediments to groundwater flow.

Waste disposal contracts were negotiated and renegotiated throughout the decommissioning projects. These changes were the result of new and less expensive disposal facilities becoming available, changes made by waste disposal vendors, changes in our understanding of the waste streams, and regulatory changes. We found that having more than one option for significant waste streams was helpful in keeping costs under control.

Having multiple waste transport options also helped to control costs and ensure that wastes could continue to be shipped under a variety of circumstances. Rail proved the best bulk option for us for shipping wastes across the country. Rail was available on site at Maine Yankee. At Connecticut Yankee and Yankee Rowe we hauled waste by truck to a nearby railhead. Intermodal containers on trucks and rail cars were used to ship waste to disposal facilities. Barge shipment was only used at Maine Yankee and Connecticut Yankee for large components such as the pressurizer, steam generators, and pressure vessel.

Early Decommissioning Planning

At Maine Yankee a construction management team started decommissioning planning in anticipation of the decision to shut down for decommissioning. This team embraced earned value performance monitoring, scrubbed the decommissioning cost estimate, and developed a decommissioning plan and schedule with a mission of being "Green" in 7 years - start to finish. The team also invited about 15 leading construction firms (either individually or as teams) to submit firm fixed-priced proposals for the entire decommissioning scope. To enable these firms to have the maximum knowledge possible when developing their bids, site characterization was undertaken. The firms interested in submitting bids were invited to participate in site characterization process to the extent that they were encouraged to attend the daily meetings and

offer suggestions as to what areas would be characterized. The site characterization report then became their bid basis.

Even though the winning firm, to be called a Decommissioning Operations Contractor or DOC, would be responsible for the decommissioning schedule, the utility management team developed a plan and detailed schedule. While many aspects of the schedule became more detailed as decommissioning progressed, MY management realized the importance of having and maintaining a clear understanding of the optimal schedule throughout the project.

As a result of this planning, it became clear that in addition to site characterization, other activities should also be completed to facilitate the demolition and decontamination (D&D) scope. The first focus had to be nuclear safety. At the time of plant shut down, all fuel was stored in the spent fuel pool because no previous dry storage activities had been implemented. The decision was made to address spent fuel storage in parallel with D&D. Therefore, a nuclear island, including the spent fuel pool and support systems, was designed and developed to maintain protection of the fuel while D&D, including original plant systems removal, was going on around it.

All three plants shut down before the end of their licensed life. None of them had an independent spent fuel storage installation or ISFSI. Fuel transfer from the spent fuel pool needed to occur during decommissioning and became critical path. During the fuel transfer phase, maintaining an operations-like focus in the midst of a decommissioning environment was critical to the success of fuel transfer and therefore the whole decommissioning project. Ideally, plants approaching decommissioning should plan to have their spent fuel pools as empty as possible so that the spent fuel pool island would not be necessary and the final fuel transfer operations won't extend the end date of the project.

Another activity that was implemented prior to the start of D&D was taking the rest of the buildings that needed to be decommissioned to a state of "cold and dark." Electricity was turned off to the buildings, components were depressurized and drained, and hazardous materials were removed. The DOC was responsible for adding temporary power sources, as need, to perform D&D. A system "re-classification and abandonment process" was important to maintaining regulatory compliance while supporting the cold and dark configuration. This process essentially removed the nuclear classification (e.g. "Safety class component") for certain systems that were important to plant operations which were no longer important to the shut down facility. Having done so, the D&D of these systems had no significance in the regulatory/license basis for the facility.

Stakeholder "buy in"

Another critical key to success in the initial planning is to engage your key Stakeholder to ensure that everyone is on the same page relative to the project objectives, regulatory interfaces, clean up criteria, issues important to the local community, etc. These relationships need to be developed early and nurtured for the entire project. Without stakeholder acceptance and confidence in the decommissioning process and activities it is difficult, if not impossible, to maintain the project schedule and continuity.

Establish a Team for Success

Construction Management Team
While effective early planning is vital to efficient decommissioning, the team doing this planning and implementing the plan is critical to success. D&D is more like construction than a nuclear plant outage. While the scheduling is similar, the planning is quite different. In both cases Industrial safety is an absolutely critical consideration throughout the work, however, in the D&D process it eclipses radiological safety toward the end of the project as radiological sources are removed and the risk is virtually eliminated.

A team of construction managers with nuclear experience worked well at Maine Yankee. They were able to get the D&D project on the right track early and maintain project momentum even through unexpected difficulties, such as DOC bankruptcy and consequent termination. In the end, the best approach is to balance people with plant knowledge who possess the right disposition for decommissioning coupled with new management to aggressively reduce, eliminate, and simplify processes where practical. A mix with "change managers" who have clear authority is essential.

Downsizing Operations Workforce

The biggest controllable cost in decommissioning is manpower. It is difficult to downsize the operating workforce as a plant moves into decommissioning – particularly when the shut down for decommissioning is unexpected as it was for Maine Yankee. However, the plants that have been slow to efficiently accomplish this downsizing have had higher decommissioning costs. Maine Yankee developed an early de-staffing plan that retained needed workers and released the rest. Severance packages, early retirement, and worker transition services helped workers make the transition. The major downsizing occurred over about a three month period. While downsizing is never easy, workers generally seemed to cope best with the transition when they understand their expected duration of employment and recognize early on that the end is near.

Another advantage to early and aggressive downsizing is that it opens up opportunities to bring in workers with skill sets that are more suited to a decommissioning environment. Also, if these workers are contractors, then tend to be more accustomed to completing a given scope of work and moving on to another job. They tend to have less of an "employment for life" mindset.

Of course, some plant operations workers will be needed for some time in decommissioning. Maine Yankee retained a few workers from almost every operating plant department throughout decommissioning, particularly maintenance, radiation protection, licensing, finance, and quality assurance. Operators were particularly helpful for tagging out equipment, draining systems, and managing groundwater and process water discharges.

Some nuclear plant operations skills are helpful in decommissioning. Verbatim procedure compliance is essential in decommissioning as it is in operations. This presents two challenges: having credible procedures, and teaching construction workers that they must follow them. In general, most plant operations procedures are not applicable to decommissioning. At Maine Yankee and Connecticut Yankee the site characterization, fuel transfer as well as some decommissioning activities were delayed while procedures were revised or developed to deal with activities that were not anticipated while the plants were in operations. Since verbatim procedure compliance is not optional, procedures vary in terms of the level of specificity and work controls. For example, activities involving the safety of nuclear fuel require more controls than other industrial work activities where "skill of the craft" is sufficient to accomplish a given task.

But the real success in human resource management is the staffing forecast. All positions had end dates in the ones I used. We openly communicated the end dates and updated them on a quarterly basis. Everyone knew where they stood. This reduced uncertainty and anxiety, and helped foster trust with senior management. It makes good sense for both the Company and its workers.

Decommissioning Management: Set clear, realistic goals and monitor performance routinely

As they say: "Safety is no accident"

Industrial Safety:

Decommissioning work can be dangerous, but all three projects which I have been involved in have been safe. This includes industrial and radiation safety of workers, nuclear safety, environmental protection, and public safety. Cost and schedule, although critical measures of success, are less important than personnel safety. It is vital to convince everyone on the project that it takes day-by-day focus and managers "walking the talk" to establish a strong safety culture. Pre-job briefings involving the workers and project supervisors should occur before each new job. Daily briefings are important in identifying potential changed conditions. It is important that every worker be empowered to stop a job if they feel unsure about the safety. Managers, likewise, are expected to be safe themselves, insist that workers be safe, and get out in the field to validate that their expectations are being met. Requirements that all site managers spend time in the field every day and that at least one manager was in the field every hour of the workday to verify performance in the field is consistent with the Safety requirements was one method we use to drive the safety message.

Radiological Safety:
We found that managers needed to be as frugal with project dose as they were with project dollars. Health physicists who understood the work allocated dose to each project and monitored its use at least weekly. The dose budgets for all the jobs were summed up for an overall annual dose goal which was then reduced by 15 to 25 percent to encourage dose savings. As with dollars, dose is not used in a linear manner throughout a particular job in that various stages of a job demanded varying exposures depending on the dose of a given task. Dose goals were not considered met for a particular job until the entire job was completed.

Total project dose estimated early in the projects tended to be conservatively high. As radioactive sources were removed and low-dose work practices improved, the actual exposures tended to drop. Strategic use of special robotic tooling was helpful in addressing highly-contaminated components or structures, thus allowing us to eliminate "hot spots" early on a reduce the exposure to the workers.

<u>Project Approach</u>
Decommission Operations Contractor:
Two of the three projects were started with a general or Decommissioning Operations Contractor (DOC). In both cases the DOC contract was terminated and the remaining work was done via self-performance. The lessons learned outlined above, i.e. good planning by a strong team, should help to ensure the success of either approach.

Firm Fixed-Priced Contracts:
Firm fixed-priced contracting is important to risk sharing and cost control where project scopes can be well defined by project management. Firm fixed-priced contracting is difficult in first of a kind activities or when well defined activities are undertaken in substantially different economic environments for the first time. Here again good planning, detailed cost understanding, and schedules developed by a knowledgeable management team will lead to more successful firm fixed-priced jobs. Even if management chooses not to employ firm fixed-priced contracting for the entire D&D scope, it can be employed successfully in major portions of the work.

Earned Value Performance Monitoring:
Comparing actual spending to budgeted or planned spending isn't good enough. In fact, it can lead one to draw the wrong conclusions. All of our spending was measured relative to the work being performed. Each scope of work in the Decommissioning had an establish cost, based on the initial Total Cost to Complete Estimate, for which performance was tracked. Earned value performance monitoring provided us with the best understanding of project progress. This method is particularly useful with firm fixed-priced contracting when both parties agree to the concept and the earned value metrics. Here again, management needs to know enough about the project to develop credible earned value/cost metrics. Earned value percent complete also provided stakeholders, particularly our boards of directors, with an understanding of project status and progress.

Project Cost Control:

Project cost control needs to be integrated up front into project planning and must be continually reinforced. We held monthly budget meetings where managers of subprojects were held accountable for their performance and given assistance if required. The project cost control professionals are more than "bean counters." They need to understand cost estimating as well as the project and field operations well enough to anticipate potential cost problems and help field supervisors stay ahead of them.

Financing:
Since these three plants were shutdown prior to their planned operating lives, decommissioning funds were initially inadequate to finance the total costs for decommissioning. Through a rate regulatory process, costs were reviewed and generally accepted as allowable to be billed to electric customers. Success in completing the projects leads to a higher acceptance that ratepayer costs are being minimized. Today, all three projects have substantially paid for their decommissioning costs and are now building reserves to store spent nuclear fuel for years into the future.

Stakeholder involvement

The stakeholders we worked with included our employees, contractors, boards of directors, regulators, elected officials, media, and the public. We developed performance indicators to provide a simple measure of project safety and regulatory, financial and schedule performance. These indicators were the same for all groups. As a communications tool I provided straightforward monthly reports to the Board of Directors and had routine Board meetings to address project status. These reports included a narrative of progress and issues as well as a monthly update of our key performance indicators. Additionally, I met with elected officials and regulatory agencies on a regular basis to keep them apprised of project progress.

In dealing with public and media communications we found community advisory panels to be particularly effective. These groups were sponsored by the Companies, but made up of credible community leaders. The panels usually met on a periodic basis, but met more frequently early in the project and during busy times. The panels also met when a particular issue of public concern was anticipated and/or raised in the media. The meetings included briefings by project personnel on project status and issues and opportunities for the panel members and public to ask questions and provide input. Initially, the exchanges could be heated, but over time, as the panel members and others became convinced that we would provide responsive information, the tone became more civil. Also, media representatives who attended these meetings provided the information and context to the public.

In Summary: Key challenges for D&D work:

- Transitioning from Operations to Decommissioning
- Verbatim compliance: Develop clear procedures, work instructions, and expectations, and hold workers, supervisors and managers accountable for compliance
- Developing a strong de-construction-focused project team while maintaining an operations-focused fuel storage and transfer group
- Building morale of many workers (goal is job elimination not longevity)
- Planning for significant waste volumes with limited waste disposal options
- Integrating site closure with full resolution of all radioactive, non-radioactive and groundwater remediation issues
- Securing stakeholder approval for the financing of decommissioning due to initial funding shortfalls caused by the earlier than scheduled permanent shutdowns
- Using large scale demolition equipment while still maintaining radiation exposure controls