ZION*Solutions*: A UNIQUE LICENSE STEWARDSHIP DECOMMISSIONING APPROACH

Tim Carraway, John Hess
Energy*Solutions*
Columbia, SC 29210

Abstract

The Zion Nuclear Station is a two-unit Pressurized Water Reactor (PWR) site that is located 40 miles north of Chicago in Zion, Illinois. Both Zion units were licensed for operation in 1973 and operated by Exelon until the decision to permanently shut down the station was made in January 1998. Since then the Zion Nuclear Station has been in SAFSTOR status.

On September 1, 2010, the Zion Nuclear Station's 10 CFR 50 license was transferred from Exelon to Zion*Solutions* for the purpose of expediting the decommissioning of the site.

This paper will discuss the License Stewardship approach that is currently being utilized by ZionSolutions to decommission the Zion Nuclear Station. A primary attribute of the License Stewardship approach involves a single company with decommissioning as their core competency taking control of a nuclear site and assuming all risks and liabilities for the decommissioning work performed.

As the first commercial application of the License Stewardship approach, this paper will include discussions of some of the primary project elements such as the project funding method, dismantlement process and schedule, management of spent fuel, end-state conditions and license termination.

1. Introduction

The License Stewardship (or Long-Term Stewardship (LTS)) approach to commercial nuclear power plant decommissioning efforts is an innovative method that results in mitigating risk and liabilities for the utility, its rate payers and the Decontamination and Decommissioning (D&D) contractor. The LTS approach involves the transfer of a nuclear power plant's assets and liabilities, the 10 CFR 50 License, and the decommissioning trust fund to a qualified D&D Contractor. The D&D Contractor then has the responsibility to Decontaminate and Decommission (D&D) the nuclear power plant and terminate or modify the 10 CFR 50 License. Modification of the 10 CFR 50 License may be required to cover on-site storage of the spent nuclear fuel if it remains on site following the D&D process.

The LTS approach has many advantages to the utility owners, ratepayers and D&D Contractors. The multi-plant utility owners benefit by reducing their risk associated with D&D of a non-generating nuclear power plant. The utility owner can then focus their attention on making electricity at their operating (revenue producing) power plants. The ratepayers benefit from the LTS approach by minimizing or finalizing their financial responsibility for a shut-down plant. The D&D contractor benefits from the LTS approach because it allows them to focus and control their work, the schedule, and the management of the trust fund. The ultimate benefit of the LTS

approach is achieved by allowing the utility owner, and D&D Contractor to focus on their company missions based on their individual core competencies.

The role of the D&D Contractor is much more comprehensive when applying the LTS approach versus just demolition and waste management. The primary responsibilities for a contractor performing demolition and waste management include the following:

- Dismantlement of Structures and Systems
- Removal of Low Level Waste from the Site
- Transportation of Waste from Site to a Disposal or Processing Facility
- Off-Site Processing of Waste
- Final Disposal of Waste

Utilizing an LTS approach, the D&D Contractor role is expanded to include the following additional responsibilities:

- Dry Storage of Spent Nuclear Fuel
- Environmental Remediation of the Site
- Must Satisfy Current and Future Regulatory Site Requirements
- Must Satisfy Local Community Expectations
- License Termination for the Site

Prior to entering into a complex LTS agreement, all parties must perform their individual due diligence. However, both parties must decide to work together to ensure this exercise is accurate and affective. The duration of a comprehensive due diligence can take 1 to 2 years to complete assuming that the utility owner and D&D Contractor agree and dedicate reliable resources to support this effort. The results of a successful due diligence can determine if the LTS approach can or cannot be applied to a specific nuclear power site.

While there are many points and questions to be researched and resolved during the due diligence process, at a minimum, the D&D Contractor must be satisfied that the site is in an acceptable financial and physical condition to ensure proper and safe decommissioning. The D&D Contractor must be satisfied that all site specific records and documentation are correct and have been maintained. All site specific liabilities must be identified and fully understood by the D&D Contractor prior to the execution of the LTS agreement.

Since the LTS approach is funded by the Decommissioning Trust Fund, it is most important that the D&D Contractor understands and agrees with the relevant decommissioning cost estimates, and the Decommissioning Trust Fund is sufficient to complete the D&D efforts.

The U.S Nuclear Regulatory Commission (NRC) also plays a major role in the D&D of a plant where a 10 CFR 50 License transfer is applicable. As part of the D&D efforts, the NRC must receive and approve a License Transfer Application (LTA) which is prepared jointly and submitted by the utility owner and D&D contractor. The D&D Contractor must also prepare and

submit a Post Shutdown Decommissioning Activities Report (PSDAR) and a Spent Fuel Management Plan for the NRC's review and approval.

The NRC must be assured that the potential new 10 CFR 50 licensee (D&D Contractor) meets established regulatory criteria and demonstrates the requisite technical qualifications to maintain the license conditions and perform the required D&D activities. In addition, the NRC must be assured that the D&D contractor has the ability to complete the D&D project within the value of the established decommissioning trust fund which must be underpinned by a detailed baseline estimate and schedule. The new licensee must demonstrate appropriate financial qualifications and provide financial assurance without relying on the utility customers (rate payers) that backed up the original utility owner, since they are no longer contributing to the fund.

2. Case Study – Zion Nuclear Power Station

Figure 1. Zion Nuclear Station.

2.1 Background

The Zion Nuclear Station (Zion) is a two-unit Pressurized Water Reactor (PWR) site that is located 40 miles north of Chicago in Zion, Illinois. Both Zion units were licensed for operation in 1973 and operated by Exelon until the decision to permanently shut down the station was made in January 1998. This decision was based on an economic analysis of necessary plant upgrades, such as steam generator replacement, and the market conditions at the time. Following the decision to shut down the Zion Nuclear Station, the units were defueled, the Licenses where amended and permanent shutdown was certified by the U.S Nuclear Regulatory Commission (NRC). Since then the Zion Nuclear Station has been in SAFSTOR status and all fuel has remained in the stations spent fuel pool.

On September 1, 2010, the Zion Nuclear Station's 10 CFR 50 license was transferred from Exelon to Zion*Solutions* (D&D Contractor) for the purpose of expediting the decommissioning of the site. Zion*Solutions* Long-Term Stewardship (LTS) approach is based on a 10-year completion schedule commencing on the day of the license transfer. Exelon's original D&D schedule was to commence with the D&D planning phase in 2013 and start D&D operations in

2015 using a vendor-approach. The vendor-approach implies that the utility owner (Exelon) would perform as the D&D-Manager overseeing the decommissioning efforts performed by the assigned D&D vendors. As seen in the following table, the Long-Term Stewardship approach performed by Zion*Solutions* will allow for the project to commence three (3) years early and accelerate the original D&D schedule by twelve (12) years.

	Exelon's Schedule	**Zion*Solutions*' Schedule**
D&D Planning Start	2013	2010
D&D Operations Start	2015	2010
Site Restoration Complete	2032	2020

Table 1. Decommissioning Schedule.

2.2 Transfer of the 10 CFR 50 License to ZionSolutions:

The transfer of a 10 CFR 50 License between companies is a process that has been undertaken numerous times with the NRC in conjunction with the sale and transfer of operating nuclear power plants. The Long-Term Stewardship (LTS) approach provides a variation to the normal license transfer process since the license is not being transferred to a company with a background in operating a nuclear power plant. However, given the SAFSTOR condition of the plant at the time of the transfer, and the expertise required to safely decommission the plant, it was fully justifiable for the NRC to authorize the transfer of the 10 CFR 50 License from Exelon to Zion*Solutions* (a wholly owned subsidiary of Energy*Solutions*).

A critical document required by the NRC to justify transfer of the 10 CFR 50 license was the Zion Nuclear Station Post-Shutdown Decommissioning Activities Report (PSDSAR). Energy*Solutions* prepared the PSDAR, which included the site specific cost estimate and baseline schedule to perform the D&D of the Zion Nuclear Station. The PSDAR along with the estimate and schedule provided assurance to the NRC that the decommissioning and End State Conditions could be achieved as planned.

The LTS-Agreement between Exelon and Zion*Solutions* provided the means for transferring the site's assets; including all structures, equipment, tools and fixtures; the decommissioning trust fund; license interests including the license to possess Spent Nuclear Fuel; and all documentation associated with Zion Nuclear Station. The LTS-Agreement excluded the transfer of the land, which was covered under a separate Lease Agreement, and the actual ownership of the Spent Nuclear Fuel, which is retained by Exelon under a general license of ownership. The on-site

switchyard is still in use and will remain under Exelon's ownership and control for the duration of the project.

In consideration for obtaining the above assets, Zion*Solutions* assumed all liabilities associated with decommissioning of the Zion Nuclear Station, managing the spent fuel during the project, restoring the site at project completion, dealing with any environmental issues, and handling other liabilities that are detailed in the LTS-Agreement or arise during the course of the project. Closing on the LTS-Agreement was contingent upon the NRC approval of the 10 CFR 50 License transfer.

2.3 Zion End State Conditions

An important part of the LTS approach is to ensure that the utility owner and the D&D Contractor fully understand the End State Conditions of the LTS-Agreement. The End State Conditions for Zion are discussed in some detail below.

2.3.1 All site structures will be dismantled, demolished and removed to a minimum of three (3) feet below grade.

2.3.2 All Class-A, Class-B, and Class-C waste will be removed from the site.All Greater than Class-C (GTTC) waste will be packaged and placed in dry storage.

2.3.3 All spent nuclear fuel will be packaged and placed in dry storage.

2.3.4 The Zion site-land will be restored to allow unrestricted use with the exception of the Dry Fuel Storage Facility.

2.3.5 Items that will remain on the site at the completion of the D&D process will include the Dry Fuel Storage Facility, existing switchyards, roads, rail and fences. During the course of the project, additional rail spurs will be added on site to accommodate waste loading and removal. These rails will be removed with the exception of the rails needed for future movement of the Spent Nuclear Fuel. This item will be discussed in later sections.

2.3.6 The 10 CFR 50 license will be transferred back to Exelon.

2.3.7 The property is then returned to Exelon for their future beneficial re-use.

2.4 Major Phases of Work

The Zion D&D project has been divided into three major phases of work. Phase 1 includes the transfer of the spent nuclear fuel from the fuel pool to dry storage. Phase 2 includes the Decontamination & Decommissioning scope of work which allows the termination of the 10 CFR 50 license. Phase 3 includes the final non-radiological work to restore the Zion site to a re-useable condition and Greenfield status.

2.4.1 Phase 1 – Spent Fuel: Zion*Solutions* will transfer all of the used fuel assemblies from their current location in the fuel pool, to a dry storage facility that will be constructed on the Zion site. The results of this phase will place the spent fuel in a safe and secure location which will allow the complete D&D of the Zion site including the fuel pool and building where the spent fuel currently resides. The fuel pool building is currently located directly between units 1 & 2 reactor buildings. Removal of the fuel pool building will allow much easier and safer access to perform the D&D operations of the reactor buildings.

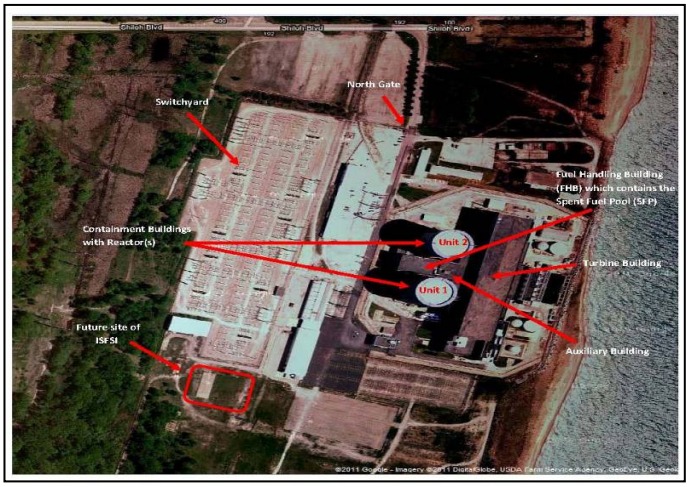
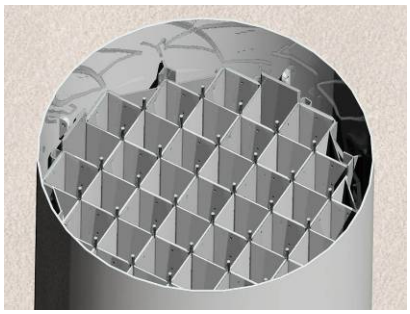


Figure 2. ISFSI Location.

There are 2,226 used fuel assemblies currently stored in the Zion fuel pool. Each fuel assembly weighs approximately 1472 pounds and the dimensions of each fuel assembly is approximately 8.5" x 8.5" x 165" long. There is also an estimated 700 cubic feet of GTCC Waste from the



Transportable Storage Canister Specifications:

- *72" Diam. X 185" High*
- *Empty Weight: 39,500 #*
- *Loaded Weight: 101,000 #*
- *Capacity: 37 Used Fuel Assemblies*

Figure 3. Storage Canister.

reactor vessels internals. The spent fuel and the Greater than Class C Waste (GTCC) require special handling and interim storage until they can be removed from the Zion site for final

disposition by the U.S Department of Energy (DOE) in accordance with the Nuclear Waste Policy Act of 1982. The canisters used to store all of the spent fuel and GTCC waste are designed to meet all transportation requirements to allow future relocation from the Zion site once the DOE depository has been identified.

Zion*Solutions* has selected the MAGNASTOR System (supplied by NAC International) for the transfer and storage of the fuel assemblies and GTCC waste. Based on the quantity of fuel assemblies and volume of GTCC waste, 61 storage canisters and concrete casks will be required for the fuel assemblies and 4 storage canisters and concrete casks will be required for the GTCC waste. Two transfer casks will also be required to safely facilitate and move the spent fuel and GTCC waste and place into the storage canisters and concrete casks.

Vertical Concrete Cask Specifications:

- *136" Diam. X 225" High*
- *Loaded Weight: 314,000 #*
- *Steel Liner: 1 ¾" Thick*
- *Concrete: 26" Thick*

Figure 4. Concrete Storage Cask.

All of the fuel assemblies and GTCC waste will be properly characterized prior to transfer to dry storage in order to develop a fuel loading plan and to ensure that the fuel assemblies meet the criteria for future off-site transport.

Prior to removal of the used fuel assemblies from the pool, 1454 of the fuel assemblies will require modification. These (1454) fuel assemblies were constructed prior to 1985 and due to construction material compatibility issues with this vintage, there have been recorded cases of breakage of the fuel assemblies lifting mechanisms. Therefore to prevent the possibility of

breakage or damage to the fuel assemblies during transfer operations, they will be structurally modified to alleviate this potential risk.

In addition to the structural modification of the pre-1985 fuel assemblies, all 2,226 of the fuel assemblies will receive a 4-sided visual inspection to ensure all fuel assemblies are structurally sound and undamaged to facilitate the transfer from the pool to the storage canister. Vacuum-Sipping will also be applied to a statistical sampling lot of approximately 500 of the fuel assemblies to look for potential damage of the fuel bundles.

In parallel with the characterization and modifications of the fuel assemblies, the MAGNASTOR System and Independent Spent Fuel Storage Installation (ISFSI) design and construction will commence. Other significant tasks that will be undertaken during the fuel assembly readiness phase include seismically upgrading the fuel building and upgrading the fuel building crane to a single-failure proof design. Upon completion of these major tasks, Zion*Solutions* will begin transferring the fuel assemblies from the fuel pool into the storage containers. The storage containers will be dried and sealed (welded) and transferred to the concrete cask with the use of the transfer cask. Then the concrete cask (containing the loaded storage container) will be transferred to the ISFSI for storage.

Design Attributes of the MAGNASTOR System:

- *Tornado: 360 mph*
- *Tornado Missiles: up to 4,000 pounds at horizontal speed of 126 mph*
- *Flooding: submerged in 50 feet of water due to flood or tsunami*
- *Fire (accidental): internal pressure within acceptable levels*
- *Seismic: 0.37g*
- *Tip-over (accidental): canister maintains structural integrity*
- *Site temperature: -40°F to +133°F*
- *Snow: >100 pcf*

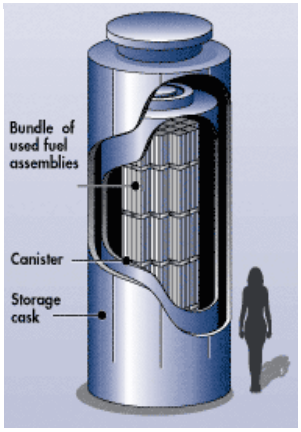


Figure 5. MAGNASTOR System.

The ISFSI, containing the spent fuel and GTCC waste will remain on the Zion site following the D&D project. Major design and security attributes of the ISFSI include the following:

- Multiple Fences
- Vehicle Barriers
- Intruder Detection Systems
- Security Monitoring Systems (24-Hour, 7-Days)
- Security Officers (24-Hour, 7-Days)

- Cooperative arrangements with local off-site law enforcement agencies
- Back-up Power Systems
- Continuous Radiation Monitoring

The following pictures depict the method used to transfer a loaded Concrete Storage Cask & Storage Canister to an ISFSI and an ISFSI located at Connecticut Yankee Nuclear Station.

Transporting Concrete Cask/Storage Canister to ISFSI Max Speed – 2 mph

Interim Spent Fuel Storage Installation – ISFSI Connecticut Yankee Nuclear Station

Figure 6. Transferring Fuel to ISFSI.

2.4.2 Phase 2 – Decontamination and Decommissioning (D&D): The D&D Phase is being performed by Zion*Solutions* employees with experience from D&D projects including Big Rock Point, Connecticut Yankee, Yankee Rowe, East Tennessee Technology Park Three Building D&D Project, plus numerous other D&D projects.

Primary activities of the D&D Phase include removal and final off-site disposition of all radioactive waste (excluding the spent fuel and GTCC waste) from the Zion site. Cost and schedule efficiencies will be achieved by utilizing large gondola rail cars and the "rip and ship"

Gondola Rail Cars used to transport Low Level Waste (LLW) off-site for final disposition

Figure 7. Gondola Rail Cars.

approach. The LTS approach benefits from taking contaminated or potentially contaminated material out in bulk and shipping it by rail to an off-site low level waste (LLW) disposal facility. This eliminates the labor intensive survey and decontamination methods used to segregate waste streams on the Zion site. This approach is based on the most significant lessons learned from previous commercial power plant decommissioning projects – which is the difficulty of successfully implementing a surgical decontamination approach on site. It also reduces schedule duration (thus cost) and eliminates the risk for inadvertent release (and liability) of radiological material to a local landfill.

Major contaminated components that will be dismantled and removed from the site during the D&D Phase include the following:

- Reactor Vessels and Internals
- Valves & Piping
- Four Main Transformers
- Main Turbines, Generators & Condensers
- Secondary Valves, Pumps, Motors & Piping
- Secondary Loop Heat Exchangers

The following table provides estimates of radioactive waste volumes expected to be generated during the D&D Phase of the project.

Estimated Radioactive Waste Volumes	
Waste Description	Volume
Class A – Equipment, Piping, Debris, Secondary Waste	4-Million Cubic Feet
Fill Materials, Concrete & Debris	2.7-Million Cubic Feet
Recycle Materials – Copper, Steel, Rebar	1.3-Million Cubic Feet
Class B/C - Reactor Vessel Internals	3200 Cubic Feet
Greater Than Class C (GTCC) – Reactor Vessel Internals	700 Cubic Feet

Table 2. Waste Estimates.

Zion*Solutions* plans to move all major components and waste by rail for disposal at an off-site low level waste (LLW) disposal facility. In order to minimize the need for multiple transportation evolutions, ZionSolutions will install a rail spur line, loading enclosures, and

logistical controls on the Zion site to facilitate enough gondola cars (approximately 50) to ship all of the waste off-site at once. These added rail spurs will be removed during Phase 3 – Site Restoration, with the exception of enough rail line to transfer the spent fuel and GTCC waste off-site in the future.

2.4.3 Phase 3 – Non-Radioactive Site Restoration: This is the final phase of the Zion Long-Term Stewardship project. With the exception of the spent fuel and GTCC waste securely located on the ISFSI, all other radioactive waste and components are scheduled to be removed from the site prior to the completion of the Site Restoration Phase. This phase includes those tasks that will prepare the site for unrestricted release and Exelon's option to utilize the site for their beneficial re-use.

Significant tasks of this phase include demolition and removal of the large structures. These large structures include the turbine buildings, crib house & trash gates, and waste water treatment facility. All remaining non-radioactive equipment will be sized appropriately for removal and rail spurs installed to facilitate the super gondola cars will be removed from site. Once all of the non-radioactive equipment and structures have been removed, Zion*Solutions* will perform final site grading and surveys to bring the Zion site to Greenfield Status.

2.5 Schedule

The Zion D&D project has a 120 month completion schedule with the end state criteria defined as the site being restored to Greenfield status, the 10 CFR 50 License amended to release the land with the exception of the ISFSI, and the land and the License returned to Exelon. The following schedule illustrates Zion*Solutions* LTS summary-timeline to accomplish this 10-year D&D project. All phases of this project will overlap and several tasks will run in parallel during the course of execution.

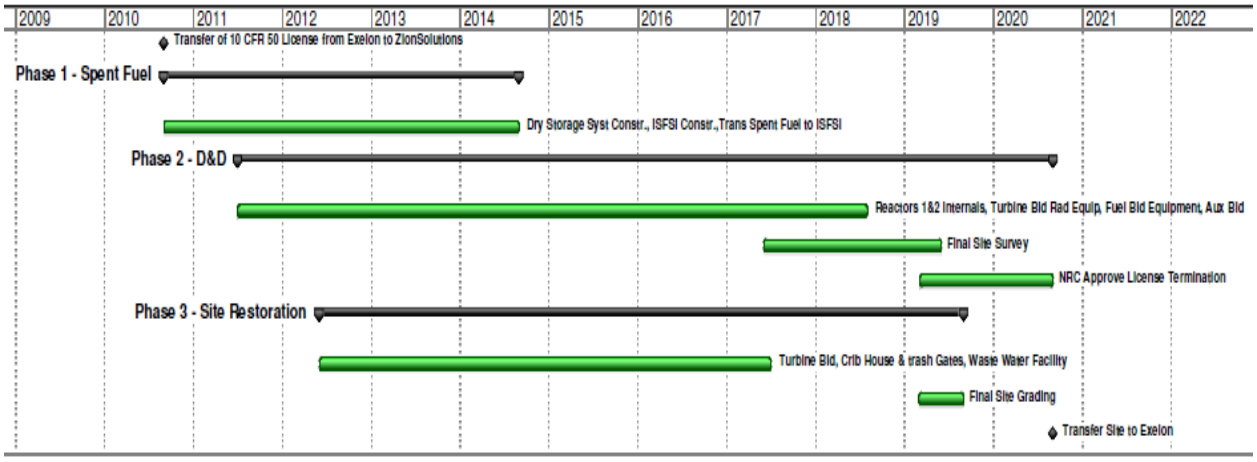


Figure 8. Zion D&D Summary Timeline.

3. Conclusion

Long-Term Stewardship (LTS) is a new approach for the decommissioning of a retired nuclear power plant that offers several key advantages to all parties. For the owner and regulators, it provides assurance that the station will be decommissioned in a safe and timely manner. Ratepayers are assured that the work will be completed for the value of the funds they have already contributed. The D&D Contractor is able to control their core competency work while achieving the desired End State Criteria for all parties – a restored site.

The Zion Nuclear Station D&D represents the largest commercial nuclear power plant decommissioning project to date within the United States. This Long-Term Stewardship (LTS) project will represent several first-time accomplishments in the nuclear industry. Some of these first-time achievements will include the following:

- The first 10 CFR 50 Long-Term Stewardship (LTS) decommissioning project;
- The first two-unit nuclear power plant to be decommissioned and;
- The largest dry fuel storage campaign to date.