# Callaway Energy Center
# Independent Spent Fuel Storage Installation
# Decommissioning Cost Analysis

Prepared for
Ameren Missouri Callaway Energy Center

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## Introduction

This report presents estimates of the costs to decommission the Callaway Energy Center (Callaway) Independent Spent Fuel Storage Installation (ISFSI) for the prompt decommissioning scenarios following the conclusion of the spent fuel transfer process to the Department of Energy (DOE). The cost estimates developed by TLG Services, Inc. are designed to provide Ameren Missouri with sufficient information to assess its financial obligations, as they pertain to the eventual decommissioning of the ISFSI.

## Site Description

The ISFSI facility is located at the Callaway Energy Center in Callaway County, Missouri, approximately 80 miles west of the St. Louis metropolitan area. The facility is located within the plant security area to the northeast of the nuclear unit.

## Regulatory Guidance

The Nuclear Regulatory Commission (NRC) issued its final rule on Decommissioning Planning on June 17, 2011,[1] with the rule becoming effective on December 17, 2012. Subpart 72.30, "Financial assurance and recordkeeping for decommissioning," requires that each holder of, or applicant for, a license under this part must submit for NRC review and approval a decommissioning funding plan that contains information on how reasonable assurance will be provided that funds will be available to decommission the ISFSI.

In accordance with the rule, a detailed cost estimate for decommissioning the ISFSI at Callaway Energy Center (Callaway) in an amount reflecting:

1. The work is performed by an independent contractor;
2. An adequate contingency factor; and
3. Release of the facility and dry storage systems for unrestricted use, as specified in 10 CFR Part 20.1402

This report also provides:

1. Identification of the key assumptions contained in the cost estimate; and
2. The volume of onsite subsurface material containing residual radioactivity, if any, that will require remediation to meet the criteria for license termination.

## Spent Fuel Management Strategy

The operating license for Callaway, renewed on March 6, 2015, is set to expire on October 18, 2044. Approximately 3,782 spent fuel assemblies are currently projected to be generated over the life of the plant. Because of the breach by the Department of Energy (DOE) of its contract to remove fuel from the site, an ISFSI has been constructed and spent fuel transferred to the dry storage modules located at the ISFSI, to support

[1] U.S. Code of Federal Regulations, Title 10, Parts 20, 30, 40, 50, 70 and 72 "Decommissioning Planning," Nuclear Regulatory Commission, Federal Register Volume 76, Number 117 (p 35512 et seq.), June 17, 2011

continued plant operations. The ISFSI will be operated under a Part 50 General License (in accordance with 10 CFR 72, Subpart K[2]).

Completion of the ISFSI decommissioning process is dependent upon the DOE's ability to remove spent fuel from the site. DOE's repository program assumes that spent fuel allocations will be accepted for disposal from the nation's commercial nuclear plants, with limited exceptions, in the order (the "queue") in which it was discharged from the reactor.[3]

In January 2013, the DOE issued the "Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste," in response to the recommendations made by the Blue Ribbon Commission on America's Nuclear Future and as "a framework for moving toward a sustainable program to deploy an integrated system capable of transporting, storing, and disposing of used nuclear fuel..."[4] The report stated, "[W]ith the appropriate authorizations from Congress, the Administration currently plans to implement a program over the next 10 years that: …[A]dvances toward the siting and licensing of a larger interim storage facility to be available by 2025 that will have sufficient capacity to provide flexibility in the waste management system and allows for acceptance of enough used nuclear fuel to reduce expected government liabilities; …"

Based upon DOE's latest strategy, Ameren Missouri believes that one or more monitored retrievable storage facilities could be put into place within a reasonable time. Ameren Missouri's current spent fuel management plan for the Callaway spent fuel is based in general upon the spent fuel being fully removed from the Callaway site by 2050.

Ameren Missouri's position is that the DOE has a contractual obligation to accept the spent fuel earlier than the projections set out above consistent with its contract commitments. No assumption made in this study should be interpreted to be inconsistent with this claim.

## ISFSI Decommissioning Strategy

At the conclusion of the spent fuel transfer process the ISFSI will be promptly decommissioned (similar to the power reactor DECON alternative).

For purposes of providing an estimate for a funding plan, financial assurance is expected to be provided on the basis of a prompt ISFSI decommissioning scenario. In this estimate the ISFSI decommissioning is considered an independent project, regardless of the decommissioning alternative identified for the nuclear unit.

## ISFSI Description

The Callaway ISFSI is based upon Holtec International's (Holtec) HI-STORM UMAX underground system for the dry storage of used nuclear fuel. In this system, spent fuel is stored in a multi-purpose container (MPC) and

[2] U.S. Code of Federal Regulations, Title 10, Part 72, Subpart K, "General License for Storage of Spent Fuel at Power Reactor Sites."

[3] U.S. Code of Federal Regulations, Title 10, Part 961.11, Article IV – Responsibilities of the Parties, B. DOE Responsibilities, 5.(a) … DOE shall issue an annual acceptance priority ranking for receipt of SNF and/or HLW at the DOE repository. This priority ranking shall be based on the age of SNF and/or HLW as calculated from the date of discharge of such materials from the civilian nuclear power reactor. The oldest fuel or waste will have the highest priority for acceptance, except as …"

[4] "Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste," U.S. DOE, January 11, 2013

placed within an underground vertical ventilated module (VVM). The ISFSI pad is designed for 48 VVMs, although all the cells may not be needed, depending upon DOE performance.

In addition to the spent fuel stored at the ISFSI, there is projected to be five additional modules used for Greater-than-Class-C (GTCC) waste storage. The multi-purpose containers used for this GTCC waste canister are also expected to be transferred to the DOE at the same time as the spent fuel transfer.

The key constituent of a HI-STORM UMAX VVM is the Cavity Enclosure Container (CEC). The CEC is a closed bottom, open top, thick walled cylindrical vessel that has no penetrations or openings. The closure lid completes the physical embodiment of the HI-STORM UMAX VVM once the loaded MPC is placed inside the CEC. The closure lid is a steel structure filled with plain concrete and is designed to protect the VVM from the impact of the design basis missiles as well as provide an inlet and outlet for air flow.

The wall thickness of the welded steel CEC is approximately ¾ inches. The CEC rests on a foundation pad with a thickness of 2 feet 9 inches, approximately 16 feet 11 inches below the grade-level ISFSI pad.

A divider shell divides the CEC into an inlet flow downcomer and an outlet flow passage. It is a vertical cylindrical shell concentrically situated in the CEC and is not attached to the CEC, which allows its convenient removal for decommissioning.

All exposed surfaces of the CEC are made from ferritic steels that are painted and protected from corrosion. The inside surface of the CECs and the divider shells is protected by paint. In addition, one side of the divider shell is further protected by insulation.

The VVMs are surrounded by controlled low-strength material (CLSM), a self-compacted, cementitious material.

A reinforced concrete slab (ISFSI pad) surrounds the upper portion of the CEC and extends to the underside of the CEC Flange. The ISFSI pad provides robust support for a loaded transporter and to enable rainwater to flow away from the storage array. The concrete ISFSI pad is approximately 2 feet 6 inches thick.

Ameren Missouri's current spent fuel management plan for the Callaway spent fuel would result in 38 MPCs being placed at the ISFSI by the year 2044, excluding GTCC.

The storage modules used for the GTCC canisters (estimated quantity of 5) are not expected to have any interior contamination of residual activation and can be reused or disposed of by conventional means after a final status survey.

Table 1 provides the significant quantities and physical dimensions used as the basis in developing the ISFSI decommissioning estimate.

## Key Assumptions / Estimating Approach

The decommissioning estimate is based on the configuration of the ISFSI expected after all spent fuel and GTCC material has been removed from the site. The configuration of the ISFSI is based on the station operating until the end of its current license (2044) and the DOE's spent fuel acceptance assumptions, as previously described.

The dry storage vendor, Holtec does not expect the VVMs to have any interior or exterior radioactive surface contamination.[5] It is expected that this assumption would be confirmed as a result of good radiological practice of surveying potentially impacted areas after each spent fuel transfer campaign. Any neutron activation of the steel and concrete is expected to be extremely small.[6] This assumption is adopted for this analysis.

The decommissioning estimate is based on the conservative premise that a small percentage of the VVMs would contain very low levels of neutron-induced residual radioactivity that would necessitate remediation at the time of decommissioning. As an allowance, 6 of the 38 MPCs are assumed to be affected, i.e., contain residual radioactivity. The allowance quantity is based upon the number of MPCs required for the final core off-load (i.e., 193 offloaded assemblies/unit, 37 assemblies per MPC) which results in a total of 6 VVMs that contain residual radioactivity. It is assumed that these are the final VVMs offloaded; consequently they have the least time for radioactive decay of the neutron activation products.

It is not expected that there will be any residual contamination left on the concrete ISFSI pad. It is expected that this assumption would be confirmed as a result of good radiological practice of surveying potentially impacted areas after each spent fuel transfer campaign. Therefore, it is assumed for this analysis that the ISFSI pad will not be contaminated. As such, only verification surveys are included for the pad in the decommissioning estimate.

The ISFSI storage modules were constructed in the original unit 2 excavation after the non-usable sediment was removed and replaced with clean fill. The clean fill was obtained from a borrow pit and suppliers located outside of the Owner Control Area and not radiologically affected by plant Operations. It is assumed that there is no subsurface soil in the proximity of the ISFSI containing residual radioactivity that will require remediation to meet the criteria for license termination.

Costs are reported in 2015 dollars and based upon a decommissioning analysis prepared for Callaway in 2014.[7]

Decommissioning is assumed to be performed by an independent contractor. As such, essentially all labor, equipment, and material costs are based on national averages, i.e., costs from national publications such as R.S. Means' Building Construction Cost Data (adjusted for regional variations), and laboratory service costs are based on vendor price lists. Ameren Missouri, as licensee, will oversee the site activities; the estimate includes Ameren Missouri's labor and overhead costs.

Low-level radioactive waste packaging, transport and disposal costs are based on rates consistent with the most recently developed decommissioning cost estimate.

Once the ISFSI NRC license is terminated and the facility released for unrestricted use, restoration of the ISFSI site area can commence. The demolition estimate assumes that the ISFSI concrete pad and CEC closure lids are demolished. The CECs and surrounding concrete are then removed to a depth of approximately three feet below the local grade. Concrete is processed for reuse as fill and steel is recovered and disposed of as scrap. Fencing, asphalt, the approach apron and any local structures are also removed with the construction and demolition materials recycled, salvaged and/or disposed of as construction debris.

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[5] Final Safety Analysis Report for the HI-STORM UMAX Canister Storage System, FSAR Report No. HI-2115090, Rev. 1, at page 2-120

[6] Ibid.

[7] "Decommissioning Cost Analysis for the Callaway Energy Center," TLG Document A22-1690-001, Rev. 0, dated March 2015

The remaining subsurface portion of the CEC is then backfilled with concrete waste. The ISFSI site area is covered with a layer of topsoil and stabilized.

Contingency has been added at an overall rate of 25%. This is consistent with the contingency evaluation criteria referenced by the NRC in NUREG-1757.[8]

## Cost Estimate

The estimated cost to decommission the ISFSI and release the facility for unrestricted use is provided in Table 2 and 3. The cost has been organized into four phases, including:

- An initial planning phase - empty VVMs are characterized and the specifications and work procedures for the decontamination (MPC support structure removal) developed.
- The remediation phase - residual radioactivity is removed. The empty VVMs are used as waste containers, transported to the low-level waste site, and disposed of at low-level waste.
- The final phase - license termination surveys, independent surveys are completed, and an application for license termination submitted.
- Site restoration - removal of structures and site facilities to a nominal depth of three feet below grade and the limited restoration of the site.

In addition to the direct costs associated with a contractor providing the decommissioning services, the estimate also contains costs for the NRC (and NRC contractor to perform the verification survey), Ameren Missouri's oversight staff, site security (industrial), and other site operating costs.

For estimating purposes it should be conservatively assumed that all expenditures will be incurred in the year 2051, the year following all spent fuel removal.

## Results

The analysis to estimate the costs to decommission Callaway ISFSI relied upon the site specific technical information and information developed for a previous nuclear unit decommissioning analysis prepared in 2014. While not an engineering study, the estimates provide the plant owner with sufficient information to assess its financial obligations, as they pertain to the eventual decommissioning of the ISFSI.

The estimates described in this report are based on numerous fundamental assumptions, including regulatory requirements, project contingencies, low-level radioactive waste disposal practices, and site restoration requirements.

The cost projected to promptly decommission Callaway ISFSI facility, assuming prompt decommissioning following the conclusion of the spent fuel transfer process to the Department of Energy (DOE)., is estimated to be $9.4 million. The majority of this cost (approximately 78%) is associated with the physical decontamination and dismantling of the ISFSI so that the operating license can be terminated. The remaining 22% is for the demolition of the designated structures and limited restoration of the site.

[8] "Consolidated Decommissioning Guidance, Financial Assurance, Recordkeeping, and Timeliness," U.S. Nuclear Regulatory Commission's Office of Nuclear Material Safety and Safeguards, NUREG-1757, Volume 3, Revision 1, February 2012

Table 1
Significant Quantities and Physical Dimensions

ISFSI Pad

| Item | Length (feet) | Width (feet) | Depth (feet) | Residual Radioactivity |
|---|---|---|---|---|
| | | | | |
| ISFSI Pad | 157.5 | 143.6 | 2.5 | No |

ISFSI HI-STORM UMAX

| Item | Value | Notes (all dimensions are nominal) |
|---|---|---|
| | | |
| Cavity Enclosure Container Inside Height (inches) | 181 | |
| Cavity Enclosure Container Inside Diameter (inches) | 86 | |
| Quantity (total) | 43 | Spent Fuel (38) + GTCC (5) |
| Quantity (with residual radioactivity) | 6 | Equivalent to the number of VVMs used to store last complete core offload) |
| Potentially Activated Steel and Concrete (pounds) | 847,767 | |
| Misc. Low-Level Radioactive Waste (pounds) | 3,289 | |
| Low-Level Radioactive Waste (cubic feet) | 13,299 | Excluding transfer cask |
| Low-Level Radioactive Waste (packaged density) | 64 | Average weight density |

Other Potentially Impacted Items

| Item | Value | Notes |
|---|---|---|
| | | |
| Number of VVMs used for GTCC storage | 5 | No residual radioactivity |

Table 2
ISFSI Decommissioning Costs[1] and Waste Volumes

| | **Costs** (thousands, 2015 dollars) | | | | | | **Waste Volume** | **Person-Hours** | |
|---|---|---|---|---|---|---|---|---|---|
| | Removal | Packaging | Transport | Disposal | Other | Total | Cubic Feet | Craft | Oversight and Contractor |
| **Decommissioning Contractor** | | | | | | | | | |
| Planning (characterization, specs and procedures) | - | - | - | - | 221 | 221 | - | - | 1,024 |
| Remediation (activated metal removal) | 528 | 97 | 94 | 2,285 | - | 3,003 | 13,299 | 7,472 | - |
| License Termination (radiological surveys) | - | - | - | - | 1,102 | 1,102 | - | 9,549 | - |
| **Subtotal** | **528** | **97** | **94** | **2,285** | **1,323** | **4,327** | **13,299** | **17,021** | **1,024** |
| **Supporting Costs** | | | | | | | | | |
| NRC and NRC Contractor Fees | - | - | - | - | 414 | 414 | - | - | 776 |
| Insurance | - | - | - | - | 119 | 119 | - | - | - |
| Property Taxes | - | - | - | - | 94 | 94 | - | - | - |
| Plant Energy Budget | - | - | - | - | 57 | 57 | - | - | - |
| Corporate A&G | - | - | - | - | 337 | 337 | - | - | - |
| Security (industrial) | - | - | - | - | 205 | 205 | - | - | 4,971 |
| Ameren Missouri Oversight | - | - | - | - | 350 | 350 | - | - | 3,771 |
| **Subtotal** | - | - | - | - | **1,575** | **1,575** | - | - | **9,519** |
| **Total (w/o contingency)** | **528** | **97** | **94** | **2,285** | **2,899** | **5,902** | **13,299** | **17,021** | **10,543** |
| **Total (w/25% contingency)** | **660** | **121** | **117** | **2,857** | **3,623** | **7,377** | | | |

Note 1: for funding planning purposes decommissioning costs can be assumed to be incurred in year 2051

**Table 3**

**ISFSI Demolition and Restoration Costs[1]**

| | **Costs** (thousands, 2015 dollars) | | | | | | **Person-Hours** | |
|---|---|---|---|---|---|---|---|---|
| | Removal | Packaging | Transport | Disposal | Other | Total | Craft | Oversight and Contractor |
| **Decommissioning Contractor** | | | | | | | | |
| Excavation and Demolition | 75 | - | - | - | - | 75 | 664 | - |
| Steel Removal | 512 | - | - | - | - | 512 | 7,523 | - |
| Concrete Processing | 110 | | | | 23 | 133 | 459 | - |
| Backfill | 284 | - | - | - | - | 284 | 618 | - |
| Tooling | - | - | - | - | 21 | 21 | - | - |
| Final Report | - | - | - | - | 24 | 24 | - | 160 |
| **Subtotal** | **981** | **-** | **-** | **-** | **67** | **1,049** | **9,265** | **160** |
| **Supporting Costs** | | | | | | | | |
| Property Taxes | - | - | - | - | - | 47 | - | - |
| Heavy Equipment | 105 | - | - | - | - | 105 | - | - |
| Plant Energy Budget | - | - | - | - | - | 28 | - | - |
| Corporate A&G | - | - | - | - | - | 169 | - | - |
| Security (industrial) | - | - | - | - | - | 102 | - | 2,486 |
| Ameren Missouri Oversight | - | - | - | - | - | 147 | - | 1,543 |
| **Subtotal** | 105 | | | | | 599 | - | 4,029 |
| **Total (w/o contingency)** | **1,087** | **-** | **-** | **-** | **67** | **1,648** | **9,265** | **4,189** |
| **Total (w/25% contingency)** | **1,250** | **-** | **-** | **-** | **78** | **2,060** | | |

Note 1: for funding planning purposes decommissioning costs can be assumed to be incurred in year 2051