

RS-22-055
April 18, 2022

10 CFR 50.54(bb)
10 CFR 50.75(f)(3)

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Clinton Power Station, Unit 1
Facility Operating License No. NPF-62
NRC Docket Nos. 50-461, 71-0008, and 72-1046

Subject: Submittal of Preliminary Decommissioning Cost Estimate and Spent Fuel Management Plan

Reference: Letter from P. Simpson (Exelon Generation Company, LLC) to U.S. NRC, "Report on Status of Decommissioning Funding for Reactors and Independent Spent Fuel Storage Installations," dated February 24, 2021 (Adams Accession No. ML21055A776)

In accordance with 10 CFR 50.75, "Reporting and recordkeeping for decommissioning planning," paragraph (f)(3), "Each power reactor licensee shall at or about 5 years prior to the projected end of operations submit a preliminary decommissioning cost estimate which includes an up-to-date assessment of the major factors that could affect the cost to decommission." Constellation Generation Company, LLC (CEG) is submitting this letter to provide a preliminary decommissioning cost estimate in accordance with 10 CFR 50.75(f)(3) and spent fuel management plan in accordance with 10 CFR 50.54(bb) for Clinton Power Station, Unit 1 (CPS), as the Facility Operating License (FOL) expires in five (5) years (April 17, 2027).

CEG has not made a final determination of the decommissioning approach for CPS. For purposes of this submittal, the SAFSTOR option has been selected. CEG reserves the right to choose an alternative decommissioning option at the actual time of decommissioning in accordance with its business needs, recognizing that it needs to assure the chosen option meets NRC requirements for decommissioning funding.

Attachment 1 of this submittal contains a preliminary decommissioning cost estimate (DCE) for CPS. The cost estimate is a preliminary estimate of anticipated costs and will be updated at various times as deemed appropriate by CEG and/or in compliance with regulatory requirements. The attached preliminary decommissioning cost estimate assumes that CPS permanently terminates operations on April 17, 2027, in accordance with the CPS FOL.

The latest Decommissioning Funding Report for CPS was submitted as Attachment 8 of the referenced letter. The minimum formula cost amount using the formula in 10 CFR 50.75(c) was calculated assuming the labor, energy, and burial factors described in Attachment 1 of the

referenced letter. The site-specific cost amount reported in the DCE is greater than the minimum formula cost amount, as required by 10 CFR 50.75(b)(1).

The major factors that could affect the cost estimate as well as contingencies to allow for unknown or unplanned occurrences during decommissioning are included in the attached preliminary DCE in Attachment 1. Additionally, soil and groundwater remediation costs are included in the cost estimate. The required soil remediation is based on evaluation of 10 CFR 50.75(g)(1) reports.

As discussed in 10 CFR 50.54(bb), "Conditions of licenses," paragraph (bb), a licensee shall "...5 years before expiration of the reactor operating license, ... submit written notification to the Commission for its review and preliminary approval of the program by which the licensee intends to manage and provide funding for the management of all irradiated fuel at the reactor following permanent cessation of operation of the reactor until title to the irradiated fuel and possession of the fuel is transferred to the Secretary of Energy for its ultimate disposal in a repository." Accordingly, Attachment 2 of this submittal includes the CPS Spent Fuel Management Plan for NRC review and preliminary approval.

Attachment 3 contains the projected annual cash flow from the CPS decommissioning trust fund for decommissioning the site based on the Attachment 1 DCE. Attachment 1, Table 6-1 costs have been escalated from June 2021 dollars to the December 31, 2021 dollars shown in Attachment 3 using an escalation rate of 1.33% (which corresponds to an APR of 2.6681%). The costs for radiological decommissioning (license termination costs) and Independent Spent Fuel Storage Installation (ISFSI) decommissioning are reflected in Attachment 3 consistent with the definition of decommissioning in 10 CFR 50.2. The cash flow analysis conservatively assumes all expenses in a year are incurred at the beginning of year (i.e., beginning of year convention) during the decommissioning period.

As of December 31, 2021, CPS decommissioning trust fund balances totaled \$719.0 million, which exceeds the amount required to complete decommissioning of the site in the attached preliminary DCE.

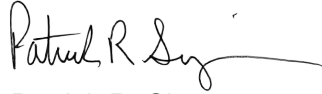
In accordance with 10 CFR 50.75(f)(1) and 10 CFR 50.82(8)(v), the financial assurance summary report will be updated and submitted to the NRC annually starting in 2023. The cost estimates and financial levels will be adjusted in accordance with Regulatory Guide 1.159, "Assuring the Availability of Funds for Decommissioning Nuclear Reactors," and will be used to demonstrate funding assurance. If the funding assurance demonstration shows the decommissioning trust fund is not sufficient, then an alternate funding mechanism allowed by 10 CFR 50.75(e) and the guidance provided in the Regulatory Guide, will be put in place at an appropriate time.

In accordance with 10 CFR 50.54(bb), a copy of this notification will be maintained until the expiration of the CPS FOL. Additionally, CPS will notify the NRC of any significant changes in the proposed Spent Fuel Management Plan described in Attachment 2.

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There are no regulatory commitments contained in this letter. Should you have any questions concerning this letter, please contact Mrs. Linda M. Palutsis at (630) 657-2821.

Respectfully,



Patrick R. Simpson
Sr. Manager – Licensing
Constellation Energy Generation, LLC

Attachments: 1. Preliminary Decommissioning Cost Estimate for Clinton Power Station
2. Spent Fuel Management Plan for Clinton Power Station
3. Decommissioning Cash Flow Analysis for Clinton Power Station

cc: Regional Administrator - NRC Region III
NRC Senior Resident Inspector - Clinton Power Station
Illinois Emergency Management Agency - Division of Nuclear Safety

Attachment 1

Preliminary Decommissioning Cost Estimate for Clinton Power Station

2021 DECOMMISSIONING COST ANALYSIS REPORT



Clinton Power Station

March 2022

APPROVALS

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EXECUTIVE SUMMARY

This report presents the cost to decontaminate and dismantle Clinton Power Station. The primary objectives of the decommissioning project are to remove the facility from service, and reduce residual radioactivity to levels permitting unrestricted release, so that the plant's operating license can be terminated within 60-years after permanent cessation of operations. The costs to restore the site to a greenfield condition are included in the cost estimate.

This report presents the SAFSTOR method for Clinton. In the SAFSTOR scenario, active decommissioning is deferred as long as possible while still meeting the required 60-year license termination.

The selection of a preferred decommissioning alternative is influenced by numerous factors including the cost of each decommissioning alternative, minimization of occupational radiation exposure, availability of a high-level waste (spent fuel) repository or an interim storage facility, the status of other units at the site, regulatory requirements, and public concerns. Based on these factors, the SAFSTOR alternative has been selected at this time. The alternative and/or plan may differ from the assumptions made in this analysis based on facts that exist at the actual time of decommissioning

The cost elements are assigned to one of five subcategories: Radiological Decommissioning (radiological remediation), Spent Fuel Management, Site Restoration, ISFSI Radiological Decommissioning, Radiological Decommissioning Planning. The Radiological Decommissioning and Radiological Decommissioning Planning subcategories are used to accumulate costs that are consistent with "decommissioning" as defined by the NRC in its financial assurance regulations (i.e., 10 CFR 50.75). The cost reported for this subcategory is generally sufficient to terminate the unit's operating license, recognizing that there may be some additional cost impact from spent fuel management.

Section 2 of this report, *Decommissioning Scenario and Schedule*, discusses three decommissioning scenarios, and provides the schedule for the selected SAFSTOR scenario. The methodology used to develop the estimated costs, including financial aspects, is discussed in Section 3, *Cost Estimate Methodology*. Section 4, *Assumptions*, provides a discussion of the assumptions used in developing the various costs elements and considerations; including the cost associated with decontamination and component removal, waste disposal, and labor. These assumptions serve as the foundation in the development of the anticipated cost to decommission Clinton.

Based on the SAFSTOR scenario, the major milestones associated with the decommissioning time periods are discussed in Section 5, *Schedule Estimate*.

The following tables summarize the estimated costs for the SAFSTOR alternative reflecting the various cost elements. Additional detail regarding the estimated costs is provided in Section 6 of this report.

SAFSTOR Alternative for Clinton
(thousands, June 2021 dollars)

Cost Element	Total
Decontamination	31,206
Removal	202,487
Packaging	26,663
Transportation	11,757
Waste Disposal	89,715
Waste Processing	16,069
Program Management ¹	479,779
Security	212,402
Spent Fuel Storage	141,746
Insurance and Regulatory Fees	61,976
Energy	25,726
Characterization and Licensing Surveys	9,453
Property Taxes	120,591
Miscellaneous Equipment and Supplies	59,057
Total²	1,488,626

Cost Element	Total
Radiological Decommissioning	1,159,064
Spent Fuel Management	209,683
Site Restoration	98,528
ISFSI Radiological Decommissioning	9,912
Radiological Decommissioning Planning	11,440
Total²	1,488,626

¹ Includes engineering costs.

² Columns may not add up due to rounding.

ACRONYMS

AE	Architect Engineer
AIF/NESP	Atomic Industrial Forum/National Environmental Studies Project
ALARA	As Low as Reasonably Achievable
BWI	Babcock & Wilcox International
BWR	Boiling Water Reactor
CE	Combustion Engineering
CEA	Control Element Assembly
CFR	Code of Federal Regulations
D.C.	District of Columbia
DCE	Decommissioning Cost Estimate
DOC	Decommissioning Operations Contractor
DOE	Department of Energy
DSAR	Defueled Safety Analysis Report
Constellation	Constellation Energy Company
FEMA	Federal Emergency Management Agency
FOL	Facility Operating License
GAO	Government Accountability Office
GTCC	Greater than Class C [Waste]
HTGR	High Temperature Gas-Cooled Reactor
IP	Industrial Package
ISFSI	Independent Spent Fuel Storage Installation
LLW	Low Level Waste
LSA	Low Specific Activity
LTP	License Termination Plan
MPC	Multi-Purpose Canister
MTHM	Metric Tons Heavy Metal
NMPC	Niagara Mohawk Power Corporation
NRC	United States Nuclear Regulatory Commission
NSSS	Nuclear Steam Supply System
NUREG	Nuclear Regulatory Report (NRC)
NWPA	Nuclear Waste Policy Act (1982)
PDCE	Preliminary Decommissioning Cost Estimate
PERT	Program Evaluation and Review Technique
PSDAR	Post Shutdown Decommissioning Activities Report
PWR	Pressurized Water Reactor
RCS	Reactor Coolant System
RPV	Reactor Pressure Vessel
SCO	Surface Contaminated Object
S&L	Sargent and Lundy
SWEC	Stone and Webster Engineering Corporation
UFSAR	Updated Final Safety Analysis Report
U.S.	United States
WDF	Work Difficulty [Adjustment] Factor

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1. OVERVIEW

This report presents decommissioning cost estimates for Clinton Power Station. The Clinton site is located in east central Illinois, in DeWitt County. The site is approximately six miles east of the city of Clinton and approximately 60 miles northeast of Springfield. The station consists of a single boiling water reactor. The site consists of approximately 14,182 acres, of which approximately 452 acres are not station property. The station property of approximately 13,730 acres is owned by Constellation. Clinton station with its associated approximately 4900-acre man-made cooling reservoir (Lake Clinton) is an irregular U-shaped site.

Clinton is a General Electric Boiling Water Reactor (BWR), owned and operated by Constellation. Clinton is licensed to generate 3473 megawatts-thermal (MWt).

The primary objectives of the decommissioning project are to remove the facility from service and reduce residual radioactivity to levels permitting unrestricted release, so that the plant's operating license can be terminated within 60-years after permanent cessation of operations. The costs to restore the site to a greenfield condition are included in the decommissioning cost estimate.

This analysis is not a detailed engineering evaluation, but an estimate prepared in advance of the detailed engineering processes required to carry out the decommissioning of the nuclear units. It also may not reflect the actual plan to decommission once Clinton is shutdown; the plan may differ from the assumptions made in this analysis based on facts that exist at the actual time of decommissioning.

The cost elements are assigned to one of five subcategories:

- (1) **Radiological Decommissioning** – this subcategory is used to accumulate costs that are consistent with “decommissioning” as defined by the Nuclear Regulatory Commission (NRC) in its financial assurance regulations (i.e., 10 CFR 50.75) and separately address the cost of radiological decommissioning as defined by 10 CFR 50.2. The cost reported for this subcategory along with the Radiological Decommissioning Planning subcategory is generally sufficient to terminate the unit's operating license, recognizing that there may be some additional cost impact from spent fuel management.
- (2) **Spent Fuel Management** – this subcategory contains costs associated with the containerization and transfer of spent fuel from the wet storage pool to a Department of Energy (DOE) transport cask or to the ISFSI for interim storage, as well as the transfer of the spent fuel in storage at the ISFSI to the DOE. Costs are included for management of the ISFSI until such time that the transfer is complete. It does not include any costs related to the final storage of the spent fuel at a national repository.
- (3) **Site Restoration** – this subcategory is used to capture costs associated with the dismantling and demolition of buildings and facilities demonstrated to be free from contamination. This includes structures never exposed to radioactive materials, as well as those facilities that have been decontaminated to appropriate levels. Structures are removed to a depth of three feet below grade and backfilled to conform to local surface elevation.
- (4) **ISFSI Radiological Decommissioning** – this subcategory is used to capture costs associated with activities directly related to radiological decontamination or dismantlement of the spent fuel dry storage facility as required by 10 CFR 72.30.

- (5) **Radiological Decommissioning Planning** - this subcategory is used to accumulate costs associated with planning for radiological decommissioning that are incurred prior to the cessation of plant operations.

It should be noted that the costs assigned to these subcategories are allocations. Delegation of cost elements is for the purposes of comparison (e.g., with NRC financial guidelines) or to permit specific financial treatment (e.g., Asset Retirement Obligation determinations). In reality, there can be considerable interaction between the activities in the five subcategories. For example, Constellation may decide to remove non-contaminated structures early in the project to improve access to highly contaminated facilities or plant components. In these instances, the non-contaminated removal costs could be reassigned from Site Restoration to a Radiological Decommissioning support activity. However, in general, the allocations represent a reasonable accounting of those costs that can be expected to be incurred for the specific subcomponents of the total estimated program cost, if executed as described.

The estimates were developed, and costs are presented in 2021 dollars. As such, the estimates do not reflect the escalation of costs (due to inflationary and market forces) over the remaining operating life of the station or during the decommissioning period.

2. DECOMMISSIONING SCENARIO AND SCHEDULE

2.1. DECOMMISSIONING METHODS

Constellation evaluated the following decommissioning scenarios:

- (1) **DECON** – spent fuel is transferred to the ISFSI shortly after shutdown and decommissioning and dismantlement is performed concurrently with the spent fuel campaign.
- (2) **Shortened SAFSTOR (SHORTSTOR)** – spent fuel is transferred to the ISFSI and the plant facility is left intact until decommissioning starts approximately 30 years after permanent shutdown.
- (3) **SAFSTOR** – spent fuel is transferred to the ISFSI and the plant facility is left intact until the decommissioning starts sometime in the future (dormancy phase), with structures maintained in a sound condition. Decommissioning commences such that license termination is completed within the required 60-years.

The scenarios also recognize that spent fuel will be stored at the site in the spent fuel storage pool(s) and/or in an ISFSI until such time that it can be transferred to a DOE facility. The estimates also include the cost to operate and eventually decommission the ISFSI.

The selection of a preferred decommissioning alternative is influenced by numerous factors at the time of plant shutdown. These factors include the cost of each decommissioning alternative, minimization of occupational radiation exposure, availability of a high-level waste (spent fuel) repository or an interim storage facility, the status of other units at the site, regulatory requirements, and public concerns.

2.2. DECOMMISSIONING SCHEDULE

The conceptual approach that the NRC has described in its regulations divides decommissioning into three phases; 1) the initial phase begins with the permanent shutdown and through the transition to storage or decommissioning activities, 2) the next phase encompasses activities during the storage period or during major decommissioning activities, or a combination of the two; and 3) the final phase pertains to the activities involved in radiological decommissioning and license termination. The decommissioning estimates developed herein are also divided into phases or periods; however, demarcation of the phases is based upon major milestones within the project or significant changes in the projected expenditures and differs from those presented by the NRC.

The major phases as defined by the Constellation Nuclear Management Model are:

Decommissioning Planning - begins 2 years prior to shutdown when a small utility staff, the Decommissioning Transition Organization (DTO), is established to perform planning and licensing activities and ends at plant shutdown.

Shutdown through Permanent Defuel – This is a short period (< 1 month) where the plant staff defuels the reactor. The only decommissioning activity during this period is continued planning by the DTO.

Permanent Defuel through Zirconium Fire Window – this period runs from permanent defuel until the end of the Zirconium fire (Zirc fire) window when the fuel no longer has enough heat to generate Zirc fire conditions in less than 10 hours. A Decommissioning

Organization (DO) is established during this period to meet all security, emergency planning, and fire protection requirements, but also performs activities to deenergize and deactivate plant systems and initiate the pool to pad activities required to move all the spent fuel from the SFP to the ISFSI.

End of Zirc Fire Window through All Fuel on Pad – Fuel is moved from the pool to the pad, and emergency planning and insurance requirements are reduced due to the end of the Zirc fire window.

All Fuel on the Pad through License Termination – Further reduction in emergency planning and security requirements due to the fact that all fuel is in dry storage at the ISFSI. This period ends when the NRC license has been terminated.

Site Restoration – after the license has been terminated, final demolition of any non-radiological structures, site grading and preparation for reuse of the land can be completed.

2.2.1. SAFSTOR Schedule

2.2.1.1. Pre-shutdown and Period 1 (Shutdown through Transition) – Preparations

Prior to the permanent shutdown and defueling, detailed preparations are undertaken to provide a smooth transition from plant operations to site decommissioning. Preparations include the planning for permanent defueling of the reactor, revision of technical specifications applicable to the operating conditions and requirements, characterization of the facility and major components, and the development of the Post Shutdown Decommissioning Activities Report (PSDAR).

Following the final shutdown and defueling, the site will be prepared to minimize operation and maintenance to those systems/components/areas that are required to support the safe handling and management of spent fuel. Those systems/components that will not be required will be isolated and removed from service. Radiation controls will be put in place to reduce radiation and contamination in areas that will need to be accessed to support decommissioning. Areas not needed will have access restricted to minimize radiation/contamination exposure and potential safety hazards. ISFSI expansion will occur and spent fuel in the spent fuel storage pool will be transferred to the ISFSI. The security area will be adjusted to reflect protection of equipment and areas necessary to support the safe handling and management of spent fuel.

2.2.1.2. Period 2 – Dormancy Phase

The second phase identified by the NRC in its rule addresses licensed activities during a storage period and is applicable to the dormancy phase of the SAFSTOR scenario. Dormancy activities include a 24-hour security force, preventive and corrective maintenance on security systems, maintenance of necessary area lighting, general building maintenance, heating and ventilation of buildings, routine radiological inspections of contaminated structures, maintenance of structural integrity, and a site environmental and radiation monitoring program. Resident maintenance personnel will perform maintenance and inspection activities to maintain safe conditions. The transfer of the spent fuel from the spent fuel pool to the ISFSI continues during this period until complete. Additionally, the transfer of the spent fuel to a DOE facility occurs during this period.

2.2.1.3. Period 3 – Site Reactivation and Decommissioning Preparations

Prior to the commencement of decommissioning operations, preparations are undertaken to reactivate site services and prepare for decommissioning. Preparations include engineering and planning, a detailed site characterization, and the assembly of a decommissioning management

organization. Final planning for decommissioning activities and the writing of work packages, activity specifications and decommissioning procedures are initiated. The environmental impact associated with the planned decommissioning activities is also considered. If the consequences of a planned decommissioning activity are predicted to be greater than what is bounded by previously evaluated environmental assessments or impact statements, a license amendment would have to be submitted to the NRC for the specific activity and the environmental report would have to be updated.

2.2.1.4. Period 4 – Decommissioning Operations

This period includes the physical decommissioning activities associated with the removal and disposal of contaminated and activated components and structures. Existing facilities will be modified, and/or temporary facilities will be constructed to support decommissioning, decontamination, and dismantling activities. Components and piping systems will be decontaminated as necessary to control (minimize) worker exposure and facilitate packaging and transportation. Piping and components no longer essential to support decommissioning operations will be removed. The reactor internal and external components will be removed. Some larger Nuclear Steam Supply System (NSSS) components may be decontaminated and sealed in such a manner as to serve as their own shipping/burial containers. The reactor will be segmented, removed, and placed in shielded casks. Activated portions of the reactor and other biological shield walls will be demolished by controlled processes.

The License Termination Plan (LTP), which includes the Final Survey Plan, is developed and submitted to the NRC. Once the survey is complete, the results are provided to the NRC for their review and evaluation. Once the NRC approves the LTP, the final remediation of site facilities and services may start. Subsequently, the NRC independently confirms the radiological site conditions and approves a license amendment that releases the property, inclusive of the ISFSI, for unrestricted use.

2.2.1.5. Period 5 – Site Restoration

Following completion of decommissioning operations, site restoration activities will begin. Remaining structures are removed, exterior walls and foundations are removed to a nominal depth of three feet below grade, and non-contaminated concrete rubble produced by demolition activities is processed and then used to backfill foundation voids. The plant area is graded and vegetation is established to inhibit erosion.

3. COST ESTIMATE METHODOLOGY

3.1. METHODOLOGY BASES

The systematic approach used herein for assembling decommissioning estimates ensures a high degree of confidence in the reliability of the resulting costs. The costs and schedules follow the general guidance and sequence in Regulatory Guide 1.184, "Decommissioning of Nuclear Power Reactors" (Reference 7.1). The format and content of the estimates is consistent with the recommendations of Regulatory Guide 1.202, "Standard Format and Content of Decommissioning Cost Estimates for Nuclear Power Reactors" (Reference 7.2). The methodology used to develop the estimates follows the basic approach originally presented in the AIF/NESP-036 study report, "Guidelines for Producing Commercial Nuclear Power Plant Decommissioning Cost Estimates" (Reference 7.3) and the DOE "Decommissioning Handbook" (Reference 7.4).

The unit cost factors used in this analysis incorporate site-specific costs and the latest available information about worker productivity in decommissioning. The detail provided in the unit cost factors, including activity duration, labor costs (by craft), and equipment and consumable costs, ensures that essential elements have not been omitted. The activity-dependent costs were estimated with the item quantities based on plant drawings and inventory documents. Removal rates and material costs for the conventional disposition of components and structures are based on cost data from RSMMeans (Reference 7.5).

Critical path was used to determine the total decommissioning program schedule and establish carrying costs, which include program management, administration, field engineering, equipment rental, quality assurance, and security.

3.2. FINANCIAL COMPONENTS OF THE COST MODEL

The cost model used provides distinct cost elements, however these distinct cost elements do not comprise the total estimated cost to accomplish the project goal. Additional factors as described below are also taken into consideration.

3.2.1. Contingency

Contingencies are necessary to provide assurance that sufficient funding will be available since the cost elements are based on ideal conditions and maximum efficiency. They are an integral part of the total cost to complete the decommissioning process and are expected to be fully expended. A contingency is then applied on a line-item basis. Contingency, in this analysis, is not intended to address changes in price escalation and inflation in the cost of decommissioning over the remaining operating life of the station, or duration of the decommissioning program and dry fuel storage period.

Constellation examined the major activities (decontamination, segmentation, equipment handling, packaging, transport, and waste disposal) that necessitate a contingency. Individual activity contingencies ranged from 10% to 75%, depending on the degree of difficulty judged to be appropriate. The contingency values used in this study are as follows:

Engineering	15%
Staffing - Utility and DOC Staff	15%
Decontamination	50%
Contaminated Removal (includes contaminated component removal and contaminated concrete removal)	25%
NSSS Component Removal	25%
Reactor Segmentation	75%
Reactor Waste Packaging	25%
Reactor Waste Transport	25%
Reactor Vessel Component Disposal	50%
Contaminated Component Packaging	10%
Contaminated Component Transport	15%
Low-Level Radioactive Waste Disposal	25%
Non-Radioactive Component Removal	15%
Supplies	25%
GTCC Disposal	25%
Other - includes: Operations and Maintenance Expense, Heavy Equipment and Tooling, and Construction	15%
Energy	15%
Characterization, Licensing and Termination Surveys	30%
Taxes, Fees, and Insurance	10%
Spent Fuel Transfer Costs	15%
ISFSI Decommissioning	25%
Low-Level Radioactive Waste Processing	15%

3.2.2. Financial Risk

This cost study does not include any specific costs for financial risk since there is insufficient historical data from which to project future liabilities. Consequently, the areas of uncertainty or risk are revisited periodically and addressed through repeated revisions or updates of the base estimates.

3.2.3. Work Difficulty Factors

Work difficulty factor (WDF) adjustments have been applied to account for the inefficiencies in working in a power plant environment. WDFs were assigned to each unique set of unit factors, commensurate with the inefficiencies associated with working in confined and/or hazardous environments. The study applies WDFs to account for use of radiological dose minimization practices (e.g., radiological protection instruction, mock-up training, and use of respiratory protection and protective clothing). Changes to worker exposure limits may also impact the decommissioning cost and project schedule.

The factors and their associated range of values were developed in conjunction with the process described in AIF/NESP-036 (Reference 7.3).

3.2.4. Scheduling Program Durations

The WDF adjusted unit factors are applied against the inventory of materials to be removed in the radiologically controlled areas. The resulting work hours are used to develop the decommissioning program schedule. The scheduling of conventional removal and dismantling activities are based upon productivity information from RSMeans (Reference 7.5). Dismantling of the fuel handling systems and decontamination of the spent fuel pools is dependent upon the timing of the transfer of the spent fuel assemblies to the ISFSI.

The program schedule is used to determine the period-dependent costs for program management, administration, field engineering, equipment rental, contracted services, etc. The study relies upon regional or site-specific salary and wage rates for the personnel associated with the intended program.

4. ASSUMPTIONS

The current cost estimate assumes the unit ceases operations in 2027, and that the shutdown is pre-planned (i.e., there is no delay in transitioning the plant and workforce from operations or in obtaining regulatory relief from operating requirements, etc.). This estimate includes additional resources to support the engineering, planning, and licensing efforts. The ISFSI is assumed to remain operational until the DOE transfers the spent fuel offsite. The estimate also includes the dismantling of non-essential structures and restoration of the site.

4.1. GENERAL

4.1.1. Energy

The physical plant is assumed to be de-energized, except for those facilities associated with spent fuel storage. Minimal energy usage is assumed to support remaining plant staffing. Additional energy is required during active decommissioning.

4.1.2. Emergency Planning

Federal Emergency Management Agency (FEMA) and state and local fees associated with emergency planning are assumed to continue through the end of the Zirc fire window following the cessation of operations.

4.1.3. Insurance

Costs for continuing coverage (nuclear liability and property insurance) following cessation of plant operations and during decommissioning are included and based upon current operating premiums, and subsequent reductions based on regulatory requirements.

4.1.4. Taxes

Property taxes are included for all decommissioning periods. Tax payments decrease during decommissioning until reaching a minimum property tax payment for the site; this level is maintained for the balance of the decommissioning program.

4.1.5. NRC Fees

NRC charges are included to support the decommissioning program. The license fee is reduced based on the NRC fees for a reactor in a decommissioning (possession-only status). The charges associated with NRC professional services for inspections and reviews are based on the NRC hourly rate and the anticipated level of participation commensurate with the decommissioning alternative and schedule.

4.1.6. Contaminated Soil

The estimate includes an allowance for the remediation of contaminated soil at the site as documented in the 10 CFR 50.57(g) file. This portion of the estimate may be affected by continued plant operations and/or future regulatory actions.

4.2. LABOR COSTS

For purposes of this analysis, it is assumed that Constellation will hire a Decommissioning Operations Contractor (DOC) to manage the decommissioning. Constellation will provide site security, radiological health and safety, quality assurance and overall site administration during the decommissioning and demolition phases. Constellation provides the total site scope during

planning, transition periods, and dormancy periods. Contract personnel will provide engineering services under the direction of Constellation.

Average Constellation labor costs are based on industry wide average salaries. Craft labor rates are based on the current Constellation craft labor contract. DOC labor costs were based on industry wide average salaries. All costs include adders for pension and benefits, payroll taxes, corporate overhead, per diems, and profit where applicable. All labor costs are adjusted to account for regional differences between the sites. A profile of the projected staffing level for decommissioning is provided in Figure 4.1

4.3. TRANSITION ACTIVITIES

Those systems and components that are not needed for the safe storage and handling of spent fuel will be removed from service and deactivated. Hazardous fluids will be drained and removed from retired plant equipment. Operating waste inventories will be processed by plant staff during the transition period.

Operation and maintenance costs for the spent fuel pool(s) are included within the estimates until the spent fuel has been transferred to the ISFSI.

The perimeter fence and in-plant security barriers will be moved, as appropriate, to conform to the Site Security Plan in force during the various stages of the project.

4.4. NON-RADIOACTIVE WASTE

4.4.1. Processed Water

It is assumed that all water released will meet the state and federal release limits. These estimates assume that processed water which meets state and federal release limits is disposed of without additional cost.

4.4.2. Asbestos Abatement

An allowance for the removal of asbestos has been added to the estimates to account for the removal and disposal costs.

4.4.3. Scrap and Salvage

Metallic material generated is processed to the greatest extent possible to reduce the total cost of controlled disposal. Material meeting the regulatory and/or site release criterion, is released as scrap, requiring no further cost consideration.

The existing plant equipment is considered obsolete and suitable for scrap as deadweight quantities only. No credit is taken for salvage value since it would be speculative, and any recovered value would be small in comparison to the overall decommissioning expenses.

4.5. RADIOACTIVE WASTE

The objectives of the decommissioning process are the removal of all radioactive material from the site that would restrict its future use and the termination of the NRC license. Most of the materials being transported for controlled burial are categorized as Low Specific Activity (LSA) or Surface Contaminated Object (SCO) materials containing Type A quantities of radioactive material.

The waste material generated in the decontamination and dismantling of the site is primarily generated during Period 4. Material that is considered potentially contaminated is sent to processing facilities in Tennessee for conditioning and disposal. Heavily contaminated components and activated materials are routed for controlled disposal.

The volumes of radioactive waste generated during the various decommissioning activities are calculated based on the container size and are summarized consistent with 10 CFR 61 classifications. Table 4.1 provides the radwaste volumes by class expected to be generated during decommissioning.

4.5.1. Low-Level Radioactive Waste Disposal

A significant portion of the waste material may only be potentially contaminated by radioactive materials. This waste can be analyzed on site or shipped off site to licensed facilities for further analysis, for processing and/or for conditioning/recovery. The estimates reflect the savings from waste recovery/volume reduction when feasible.

All options and services currently available to Constellation were taken into consideration regarding the disposition of the various waste streams produced by the decommissioning process. Disposal fees are calculated using representative costs. The disposal costs for Class A, B and C waste were based upon a representative Constellation fleet cost. Class A waste is assumed to be disposed of at a facility in Utah. This facility is not licensed to receive Class B and C wastes. Class B and C waste is assumed to be disposed of at a facility in Texas.

The waste volumes are calculated based on the exterior package dimensions for containerized material or a specific calculation for components serving as their own waste containers.

4.5.2. Greater Than Class C Radioactive Waste

The dismantling of the components residing closest to the reactor core generally generates radioactive waste considered unsuitable for shallow-land disposal (i.e., low-level waste with concentrations greater than the NRC limits for Class C waste (i.e., GTCC)). A small quantity of material generated during decommissioning will be GTCC waste; GTCC waste is expected to be a small percentage of the total waste volume. GTCC waste is assumed to be placed in spent fuel storage canisters and disposed of in a similar manner to that envisioned for spent fuel disposal.

The federal government has the responsibility for the disposal of this material. However, the federal government has not identified a cost for disposing of GTCC, a schedule for acceptance, nor acceptance criteria for this material. For purposes of this analysis, the GTCC radioactive waste is assumed to be packaged and disposed of in a similar manner as high-level waste and at a cost equivalent to that envisioned for the spent fuel.

GTCC canisters will remain in storage until such time the DOE is ready to accept GTCC waste; it is assumed that the DOE would not accept this waste prior to completing the transfer of spent fuel.

4.5.3. Transportation Methods

The transport of all waste material and components will be by a combination of truck and/or multi-wheeled transporter. Transportation costs for material requiring controlled disposal or processing are based upon the mileage to the respective disposal or processing site.

4.6. COMPONENT REMOVAL

4.6.1. Reactor Vessel and Internal Components

The curie contents of the reactor vessel and internals are derived from those listed in NUREG/CR-3474, "Long-Lived Activation Products in Reactor Materials," (Reference 7.6) and are based on a generic model for the reactor design. Additional short-lived isotopes were derived from NUREG/CR-0130, "Technology, Safety and Costs of Decommissioning a Reference Pressurized Water Reactor Power Station," (Reference 7.7) and NUREG/CR-0672, "Technology, Safety and Costs of Decommissioning a Reference Boiling Water Reactor Power Station," (Reference 7.7) and benchmarked to the long-lived values from NUREG/CR-3474 (Reference 7.6).

The reactor pressure vessel and internal components are assumed to be segmented for disposal in shielded, reusable transportation casks. Transportation cask specifications and transportation regulations dictate the segmentation and packaging methodology. Due to the uncertainty in the viability of disposing of the reactor vessel and internals as a self-contained package, segmentation is assumed as a bounding condition.

The disposal cost for the control blades removed from the vessel with the final core load are included within the estimates. Control blades are not Greater than Class C (GTCC) material.

4.6.2. System Components

Reactor piping and other NSSS components will be removed. Specialized equipment will be brought in as necessary. With proper closure of all openings, access ways, and penetrations, some larger components may be used as their own shipping and burial containers.

Radioactive piping and components will be removed using methods appropriate with their potential contamination level. Non-contaminated piping and components will be removed using conventional dismantlement and removal processes.

Components will be packaged and readied for transport in accordance with the intended disposition.

4.6.3. Retired Components

Any components that have been replaced and where the original components are stored on site at the time of shutdown are included in the cost of decommissioning. Since the components have already been removed from the plant, only packaging, disposal, and transportation costs are included for the components.

4.7. SPENT FUEL MANAGEMENT

Since the DOE is ultimately responsible for spent fuel disposal, the cost to dispose of spent fuel is not reflected within the estimates. However, the costs for spent fuel management while the fuel remains onsite are included and identified separately as "Spent Fuel Management."

Constellation assumes, for the purposes of this estimate, that the spent fuel will be packaged into multi-purpose containers (MPCs) over the first 3 to 5 years after shutdown. It is assumed that this period provides the necessary cooling for the spent fuel from the final core to meet the transport and/or storage requirements for decay heat. The estimates include the cost for the labor and equipment to transfer and load each MPC and relocate it to the ISFSI. For estimating purposes, an allowance is used to estimate the cost to transfer the fuel containers from the ISFSI onto the transport vehicle.

Given the status of the DOE spent fuel program, Constellation estimates that 2035 will be the most likely year when the DOE begins spent fuel removal from the industry. Constellation assumed that the DOE's repository will have a maximum annual capacity of receiving 3,000 metric tons of uranium from the industry (Reference 7.9) and that the repository will accept spent fuel in the order in which it was removed (oldest fuel first). Additionally, Constellation assumes that it is able to re-assign its DOE spent fuel allocations between its large fleet of units to minimize on-site storage costs.

Based on the above, the spent fuel is projected to remain onsite until the end of 2044. Any delay in transfer of fuel to DOE or decrease in the rate of acceptance will result in spent fuel remaining at the site longer.

4.8. INDEPENDENT SPENT FUEL INSTALLATION

4.8.1. Construction, Operation and Maintenance

An ISFSI has been constructed on site to support storage of all spent fuel. Expansion of the ISFSI is modeled to support the transfer of all the fuel in the SFP to the ISFSI. The ISFSI will continue to operate until such time that the transfer of spent fuel to the DOE can be completed. Operation and maintenance costs for the ISFSI are included as "Spent Fuel Management" expenditures in the estimates.

4.8.2. ISFSI Decommissioning

The ISFSI site and associated facilities also must have a proposed decommissioning plan. The cost estimate for decommissioning the ISFSI reflects: 1) the cost of an independent contractor performing the decommissioning activities, 2) an adequate contingency factor (see Section 3.2.1), and 3) the cost of meeting the criteria for unrestricted use.

4.9. SITE RESTORATION

The cost for the site restoration of non-contaminated structures has been calculated and is separately presented as "Site Restoration" expenditures in this report.

While some structures may be dismantled, and the costs included in the decontamination process, the dismantlement of the remaining site structures are included in the site restoration costs. All structures are assumed to be removed to a nominal depth of three feet below grade and the voids backfilled with clean debris then topped with soil. Bulk excavation of soil and material in the immediate vicinity of the reactor building is included to remove various duct banks, catch basins, and underground utilities that may exist. The site will then be graded to conform to the adjacent landscape and vegetation is established to inhibit erosion.

Site utility and service piping are abandoned in place and manholes are backfilled. Asphalt surfaces and facility roads, except for the site access road, will be broken up and the material used as backfill on site.

The existing electrical switchyard is assumed to remain functional in support of the regional electrical distribution system.

4.10. SITE CONDITIONS FOLLOWING DECOMMISSIONING

Once the NRC determines that site radiological remediation has been performed in accordance with the LTP and the final radiation survey demonstrates that the facility is suitable for release, the NRC will terminate the facility license(s) (or amend the license(s) if an ISFSI is still present). Building codes and environmental regulations will dictate the remaining actions in the decommissioning process.

Figure 4-1 : Total Labor Hours

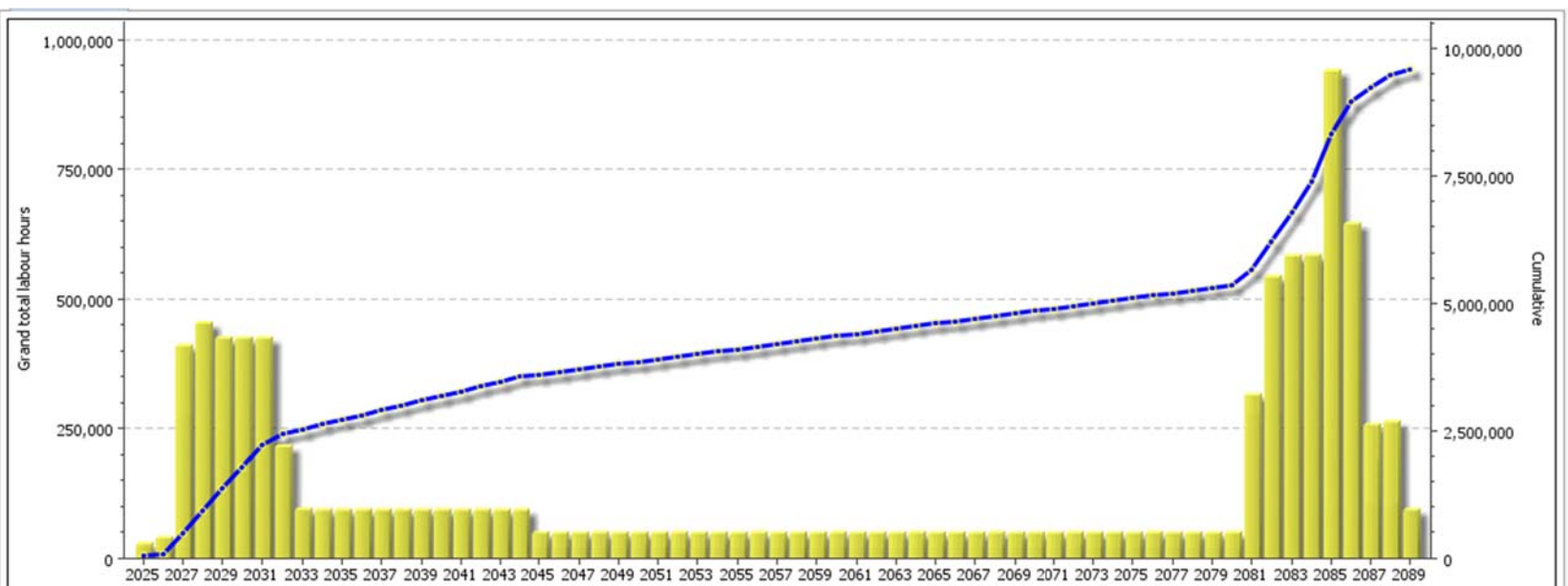


Table 4-1: Burial Volumes by Waste Category

Class / Type	Volume (cf)	Mass (lb)
A / Bulk	73,724	3,555,299
A / Containerized	228,252	11,587,125
A / DAW	34,449	688,975
A / Lead	353	250,000
A / Oil	2,005	125,175
A / Processed	520,935	21,570,635
B	2,224	342,699
B / Resin	2,906	191,807
C	840	129,346
GTCC	2,534	518,021
Total / Disposal	868,222	38,959,081

5. SCHEDULE ESTIMATE

5.1. SCHEDULE ASSUMPTIONS

The schedules for the decommissioning scenarios follow the sequence presented in the AIF/NESP-036 study, with minor changes to reflect recent experience and site-specific constraints. In addition, the scheduling has been revised to reflect spent fuel management plans.

The work activity durations are based on adjusted actual person-hour estimates. Durations are established between several milestones in each decommissioning period; these durations are used to establish a critical path for the entire project. In turn, the critical path duration for each period is used as the basis for determining the period-dependent costs. A second critical path is also used for the spent fuel cooling period, which determines the release of the spent fuel building for final decontamination. The project schedule is included in Table 5-1.

Table 5-1: Decommissioning Timeline

Plant Status / Decommissioning Activities	Start	End	Approximate Duration (years)
Pre-Shutdown			
Pre-Shutdown Planning	Apr 2025	Apr 2027	2.0
Preparations for Dormancy			
Plant Shutdown / Defueling Outage	Apr 2027	Apr 2027	0.1
System Abandonments and Fuel Transfer to ISFSI	May 2027	Apr 2032	5.0
Final System Abandonments	May 2032	Jan 2033	0.7
Dormancy			
Dormancy w/ Dry Fuel Storage	Feb 2033	Mar 2043	10.2
Fuel Shipping	Apr 2043	Dec 2044	1.7
Dormancy w/ No Fuel	Jan 2045	Mar 2081	36.2
Decommissioning Preparations			
	Mar 2081	Mar 2082	1.0
Decommissioning Operations			
Large Component Removal	Mar 2082	Jan 2085	2.8
Plant Systems Removal and Building Decontamination	Jan 2085	Jul 2086	1.5
License Termination	Jul 2086	Apr 2087	0.8
Total from Shutdown to Completion of License Termination			60
Site Restoration			
	Apr 2087	Apr 2089	2.0

6. COST ESTIMATE

The estimate presented in this document reflects the total cost to decontaminate the nuclear unit, manage the spent fuel until the DOE transfers it to a federal facility, dismantle the plant, and restore the site for alternative use. Costs are not inflated, escalated, or discounted over the period of expenditure (or projected lifetime of the plant).

Table 6.1 summarizes the estimated costs for the SAFSTOR scenario reflecting the various cost elements. Table 6.2 provides yearly expenditures broken down by cost contributor. The detailed cost estimate is provided in Table 6.3.

Table 6-1: SAFSTOR Alternative for Clinton
(thousands, June 2021 dollars)

Cost Element	Total
Decontamination	31,206
Removal	202,487
Packaging	26,663
Transportation	11,757
Waste Disposal	89,715
Waste Processing	16,069
Program Management ¹	479,779
Security	212,402
Spent Fuel Storage	141,746
Insurance and Regulatory Fees	61,976
Energy	25,726
Characterization and Licensing Surveys	9,453
Property Taxes	120,591
Miscellaneous Equipment and Supplies	59,057
Total²	1,488,626

Cost Element	Total
Radiological Decommissioning	1,159,064
Spent Fuel Management	209,683
Site Restoration	98,528
ISFSI Radiological Decommissioning	9,912
Radiological Decommissioning Planning	11,440
Total²	1,488,626

¹ Includes engineering costs.

² Columns may not add up due to rounding.

Table 6-1: Total Annual Expenditures
(thousands, June 2021 dollars)

Year	Radiological Decommissioning	Spent Fuel Management	Site Restoration	ISFSI Radiological Decommissioning	Radiological Decommissioning Planning	Total
2025	0	0	0	0	3,942	3,942
2026	0	0	0	0	5,533	5,533
2027	56,873	75,237	64	0	1,966	134,140
2028	60,477	22,005	32	0	0	82,514
2029	52,141	3,920	19	0	0	56,080
2030	48,325	15,354	19	0	0	63,698
2031	43,508	20,952	19	0	0	64,478
2032	24,130	9,575	78	0	0	33,783
2033	7,328	3,920	9	0	0	11,256
2034	6,607	3,920	0	0	0	10,527
2035	6,607	3,920	0	0	0	10,527
2036	6,625	3,931	0	0	0	10,556
2037	6,607	3,920	0	0	0	10,527
2038	6,607	3,920	0	0	0	10,527
2039	6,607	3,920	0	0	0	10,527
2040	6,625	3,931	0	0	0	10,556
2041	6,607	3,920	0	0	0	10,527
2042	6,607	3,920	0	0	0	10,527
2043	6,133	10,600	0	0	0	16,733
2044	5,994	12,820	0	0	0	18,814
2045	7,154	0	0	0	0	7,154
2046	7,154	0	0	0	0	7,154
2047	7,154	0	0	0	0	7,154
2048	7,174	0	0	0	0	7,174
2049	7,154	0	0	0	0	7,154
2050	7,154	0	0	0	0	7,154
2051	7,154	0	0	0	0	7,154
2052	7,174	0	0	0	0	7,174
2053	7,154	0	0	0	0	7,154
2054	7,154	0	0	0	0	7,154
2055	7,154	0	0	0	0	7,154
2056	7,174	0	0	0	0	7,174
2057	7,154	0	0	0	0	7,154
2058	7,154	0	0	0	0	7,154
2059	7,154	0	0	0	0	7,154

Table 6-2: Total Annual Expenditures (cont)
(thousands, June 2021 dollars)

Year	Radiological Decommissioning	Spent Fuel Management	Site Restoration	ISFSI Radiological Decommissioning	Radiological Decommissioning Planning	Total
2060	7,174	0	0	0	0	7,174
2061	7,154	0	0	0	0	7,154
2062	7,154	0	0	0	0	7,154
2063	7,154	0	0	0	0	7,154
2064	7,174	0	0	0	0	7,174
2065	7,154	0	0	0	0	7,154
2066	7,154	0	0	0	0	7,154
2067	7,154	0	0	0	0	7,154
2068	7,174	0	0	0	0	7,174
2069	7,154	0	0	0	0	7,154
2070	7,154	0	0	0	0	7,154
2071	7,154	0	0	0	0	7,154
2072	7,174	0	0	0	0	7,174
2073	7,154	0	0	0	0	7,154
2074	7,154	0	0	0	0	7,154
2075	7,154	0	0	0	0	7,154
2076	7,174	0	0	0	0	7,174
2077	7,154	0	0	0	0	7,154
2078	7,154	0	0	0	0	7,154
2079	7,154	0	0	0	0	7,154
2080	7,174	0	0	0	0	7,174
2081	37,834	0	64	0	0	37,898
2082	94,852	0	505	0	0	95,356
2083	106,856	0	607	0	0	107,463
2084	107,149	0	609	0	0	107,757
2085	110,714	0	2,979	2,708	0	116,402
2086	71,233	0	1,663	7,204	0	80,099
2087	8,281	0	31,741	0	0	40,022
2088	0	0	45,021	0	0	45,021
2089	0	0	15,100	0	0	15,100
Total¹	1,159,064	209,683	98,528	9,912	11,440	1,488,626

¹ Columns may not add up due to rounding.

Table 6-3: Total Cost by WBS
(thousands, June 2021 dollars)

		Decontamination	Removal	Packaging	Transportation	Waste Disposal	Waste Processing	Program Management	Security	Spent Fuel Storage	Insurance and Regulatory Fees	Energy	Characterization and Licensing Surveys	Property Taxes	Miscellaneous Equipment and Supplies	Grand total
01 - Planning & Preparation Costs	01.0101 - Utility Staff	0	0	0	0	0	0	9,754	0	0	0	0	0	0	0	9,754
	01.0801 - NRC Fees	0	0	0	0	0	0	0	0	0	1,439	0	0	0	0	1,439
	01.3201 - Contracted Engineering Analyses	0	0	0	0	0	0	247	0	0	0	0	0	0	0	247
02 - Plant Deactivation Costs	02.0101 - Utility Staff	0	0	0	0	0	0	116,762	0	0	0	0	0	0	0	116,762
	02.0102 - Security Staff	0	0	0	0	0	0	0	61,605	0	0	0	0	0	0	61,605
	02.0201 - Structure Decontamination	15,498	384	3	9	107	0	0	0	0	0	0	0	0	0	16,001
	02.0301 - Insurance	0	0	0	0	0	0	0	0	0	4,331	0	0	0	0	4,331
	02.0501 - Heavy Equipment	0	3,497	0	0	0	0	0	0	0	0	0	0	0	0	3,497
	02.0503 - Health Physics Supplies	0	316	0	0	0	0	0	0	0	0	0	0	0	0	316
	02.0504 - Maintenance Supplies	0	0	0	0	0	0	0	0	0	0	0	0	0	3,548	3,548
	02.0508 - Spent Fuel Pool O&M Supplies	0	0	0	0	0	0	0	0	0	0	0	0	0	5,559	5,559
	02.0601 - Plant Energy	0	0	0	0	0	0	0	0	0	0	12,165	0	0	0	12,165
	02.0702 - Hazardous Liquid Remediation	0	0	74	75	251	0	0	0	0	0	0	0	0	0	400
	02.0801 - NRC Fees	0	0	0	0	0	0	0	0	0	3,390	0	0	0	0	3,390
	02.1001 - Emergency Planning Fees	0	0	0	0	0	0	0	0	0	2,269	0	0	0	0	2,269
	02.1101 - Modifications	0	0	0	0	0	0	0	0	0	0	0	0	0	7,011	7,011
	02.1801 - Process Decommissioning Water Waste	0	0	28	351	3,724	0	0	0	0	8	0	0	0	3,026	7,136
	02.1901 - Site Upkeep	0	0	0	0	0	0	0	0	0	0	0	0	0	1,906	1,906
	02.2301 - Disposal of Dry Active Waste	0	0	2	4	55	0	0	0	0	0	0	0	0	0	62
	02.3701 - Severance	0	0	0	0	0	0	13,157	0	0	0	0	0	0	0	13,157
03 - Safe Storage Operations Costs	03.0101 - Utility Staff	0	0	0	0	0	0	109,342	0	0	0	0	0	0	0	109,342
	03.0102 - Security Staff	0	0	0	0	0	0	0	63,224	0	0	0	0	0	0	63,224
	03.0301 - Insurance	0	0	0	0	0	0	0	0	0	28,926	0	0	0	0	28,926
	03.0503 - Health Physics Supplies	0	2,643	0	0	0	0	0	0	0	0	0	0	0	0	2,643
	03.0504 - Maintenance Supplies	0	0	0	0	0	0	0	0	0	0	0	0	0	6,097	6,097
	03.0601 - Plant Energy	0	0	0	0	0	0	0	0	0	0	3,981	0	0	0	3,981
	03.0801 - NRC Fees	0	0	0	0	0	0	0	0	0	14,329	0	0	0	0	14,329
	03.1801 - Process Decommissioning Water Waste	0	0	14	179	1,903	0	0	0	0	0	0	0	0	2,221	4,317
	03.1901 - Site Upkeep	0	0	0	0	0	0	0	0	0	0	0	0	0	21,067	21,067
	03.2301 - Disposal of Dry Active Waste	0	0	14	38	464	0	0	0	0	0	0	0	0	0	516
04 - Dismantlement Costs	04.0101 - Utility Staff	0	0	0	0	0	0	42,028	0	0	0	0	0	0	0	42,028
	04.0102 - Security Staff	0	0	0	0	0	0	0	25,009	0	0	0	0	0	0	25,009
	04.0103 - DOC Staff	0	0	0	0	0	0	178,924	0	0	0	0	0	0	0	178,924
	04.0201 - Structure Removal	14,165	42,171	280	994	3,803	458	0	0	0	0	0	0	0	0	61,872
	04.0202 - System Removal	109	73,188	1,988	2,434	6,067	13,789	0	0	0	0	0	0	0	0	97,574
	04.0301 - Insurance	0	0	0	0	0	0	0	0	0	3,221	0	0	0	0	3,221
	04.0401 - Reactor Pressure Vessel	0	9,543	5,844	1,595	7,059	0	0	0	0	0	0	0	0	0	24,041
	04.0402 - Reactor Pressure Vessel Internals	0	9,265	16,323	3,047	41,776	0	0	0	0	0	0	0	0	0	70,412
	04.0403 - GTCC Disposal	0	0	0	0	15,580	0	0	0	0	0	0	0	0	0	15,580
	04.0501 - Heavy Equipment	0	22,781	0	0	0	0	0	0	0	0	0	0	0	0	22,781
	04.0503 - Health Physics Supplies	0	4,805	0	0	0	0	0	0	0	0	0	0	0	0	4,805
	04.0504 - Maintenance Supplies	0	0	0	0	0	0	0	0	0	0	0	0	0	976	976
	04.0507 - Plant Preparation and Temporary Services	0	4,980	3	8	96	0	0	0	0	0	0	0	0	0	5,086
	04.0601 - Plant Energy	0	0	0	0	0	0	0	0	0	0	8,561	0	0	0	8,561
	04.0702 - Hazardous Liquid Remediation	0	0	25	25	84	0	0	0	0	0	0	0	0	0	133
	04.0703 - Lead Remediation	0	0	14	77	0	109	0	0	0	0	0	0	0	0	200
	04.0801 - NRC Fees	0	0	0	0	0	0	0	0	0	3,158	0	0	0	0	3,158
	04.0901 - Asbestos	0	3,125	0	0	0	0	0	0	0	0	0	0	0	0	3,125
	04.1303 - Condenser	0	359	559	407	539	0	0	0	0	0	0	0	0	0	1,865
	04.1304 - Turbine Generator	0	355	371	542	1,186	0	0	0	0	0	0	0	0	0	2,454
	04.1304R - Retired Turbine Generator	0	0	219	237	712	0	0	0	0	0	0	0	0	0	1,168
	04.1306 - Recirc Pumps/Reactor Coolant Pumps	0	355	306	273	310	0	0	0	0	0	0	0	0	0	1,245
	04.1401 - Site Excavation	0	2,578	0	0	0	0	0	0	0	0	0	0	0	0	2,578
	04.1701 - Scaffolding	0	9,564	82	26	135	0	0	0	0	0	0	0	0	0	9,808
	04.1801 - Process Decommissioning Water Waste	0	0	22	279	2,956	0	0	0	0	0	0	0	0	2,201	5,458
	04.1901 - Site Upkeep	0	0	0	0	0	0	0	0	0	0	0	0	0	2,886	2,886

Table 6-3: Total Cost by WBS (cont.)
(thousands, June 2021 dollars)

	Decontamination	Removal	Packaging	Transportation	Waste Disposal	Waste Processing	Program Management	Security	Spent Fuel Storage	Insurance and Regulatory Fees	Energy	Characterization and Licensing Surveys	Property Taxes	Miscellaneous Equipment and Supplies	Grand total
04.2101 - Spent Fuel Rack Removal	1,435	1,197	213	439	1,290	0	0	0	0	0	0	0	0	0	4,574
04.2301 - Disposal of Dry Active Waste	0	0	13	35	436	0	0	0	0	0	0	0	0	0	484
04.2601 - DOC Relocation	0	0	0	0	0	0	732	0	0	0	0	0	0	0	732
04.2700 - Misc Decommissioning Waste	0	0	53	91	55	665	0	0	0	0	0	0	0	0	864
04.2801 - Cofferdams	0	2,266	0	0	0	0	0	0	0	0	0	0	0	0	2,266
04.2901 - Site Grading and Landscaping	0	3,714	0	0	0	0	0	0	0	0	0	0	0	0	3,714
04.3103 - Remove Rubble / Backfill Site	0	2,695	0	0	0	0	0	0	0	0	0	0	0	0	2,695
04.3300 - Radiation Surveys	0	0	0	0	0	0	0	0	0	0	0	9,340	0	0	9,340
04.3701 - Severance	0	0	0	0	0	0	3,074	0	0	0	0	0	0	0	3,074
05 - ISFSI Costs	0	0	0	0	0	0	4,159	0	0	0	0	0	0	0	4,159
05.0101 - Utility Staff	0	0	0	0	0	0	0	62,564	0	0	0	0	0	0	62,564
05.0102 - Security Staff	0	0	0	0	0	0	0	0	0	507	0	0	0	0	507
05.0301 - Insurance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05.0501 - Heavy Equipment	0	441	0	0	0	0	0	0	0	0	0	0	0	0	441
05.0504 - Maintenance Supplies	0	0	0	0	0	0	0	0	0	0	0	0	0	51	51
05.0601 - Plant Energy	0	0	0	0	0	0	0	0	0	0	1,019	0	0	0	1,019
05.0801 - NRC Fees	0	0	0	0	0	0	0	0	0	396	0	0	0	0	396
05.1201 - Fuel from Pool to Pad	0	0	0	0	0	0	0	0	124,789	0	0	0	0	0	124,789
05.1202 - Fuel from Pad to DOE	0	0	0	0	0	0	0	0	14,463	0	0	0	0	0	14,463
05.1601 - ISFSI License Termination Planning	0	0	0	0	0	0	0	0	137	0	0	0	0	0	137
05.1602 - ISFSI License Termination Radiological D&D	0	444	213	591	1,128	1,047	0	0	0	0	0	0	0	0	3,422
05.1603 - ISFSI License Termination Surveys	0	0	0	0	0	0	0	0	2,357	0	0	0	0	0	2,357
05.1604 - ISFSI Site Restoration	0	1,820	0	0	0	0	0	0	0	0	0	0	0	0	1,820
05.1901 - Site Upkeep	0	0	0	0	0	0	0	0	0	0	0	0	0	2,508	2,508
05.3202 - Contracted Engineering Analyses - ISFSI	0	0	0	0	0	0	493	0	0	0	0	0	0	0	493
05.3300 - Radiation Surveys	0	0	0	0	0	0	0	0	0	0	0	112	0	0	112
05.3701 - Severance	0	0	0	0	0	0	1,107	0	0	0	0	0	0	0	1,107
06 - Property Tax Costs	0	0	0	0	0	0	0	0	0	0	0	0	120,591	0	120,591
06.0302 - Property Taxes	0	0	0	0	0	0	0	0	0	0	0	0	120,591	0	120,591
Grand total	31,206	202,487	26,663	11,757	89,715	16,069	479,779	212,402	141,746	61,976	25,726	9,453	120,591	59,057	1,488,626

7. REFERENCES

- 7.1. Regulatory Guide 1.184, "Decommissioning of Nuclear Power Reactors," Revision 1, Nuclear Regulatory Commission, October 2013
- 7.2. Regulatory Guide 1.202, "Standard Format and Content of Decommissioning Cost Estimates for Nuclear Power Reactors," Nuclear Regulatory Commission, February 2005
- 7.3. "Guidelines for Producing Commercial Nuclear Power Plant Decommissioning Cost Estimates," AIF/NESP-036, May 1986, T.S. LaGuardia et al.
- 7.4. "Decommissioning Handbook," U.S. Department of Energy, DOE/EV/10128-1, November 1980, W.J. Manion and T.S. LaGuardia
- 7.5. Construction Cost Information, RSMeansonline.com, Gordian Company
- 7.6. NUREG/CR-3474, "Long-Lived Activation Products in Reactor Materials," Pacific Northwest Laboratory for the Nuclear Regulatory Commission, August 1984, J.C. Evans et al.
- 7.7. NUREG/CR-0130 and addenda, "Technology, Safety and Costs of Decommissioning a Reference Pressurized Water Reactor Power Station," Pacific Northwest Laboratory for the Nuclear Regulatory Commission, June 1978, R.I. Smith, G.J. Konzek, W.E. Kennedy, Jr.
- 7.8. NUREG/CR-0672 and addenda, "Technology, Safety and Costs of Decommissioning a Reference Boiling Water Reactor Power Station," Pacific Northwest Laboratory for the Nuclear Regulatory Commission, June 1980, H.D. Oak, et al.
- 7.9. Civilian Radioactive Waste Management System Requirements Document, DOE/RW-0406, Revision 8, September 2007

Attachment 2

Spent Fuel Management Plan for Clinton Power Station

1.0 Background

The Clinton Power Station, Unit 1, (CPS) Facility Operating License (FOL) expires on April 17, 2027. Constellation Energy Generation, LLC (CEG) has not made a final determination of the decommissioning approach for CPS. For purposes of this Spent Fuel Management Plan (SFMP), the SAFSTOR option has been selected. CEG reserves the right to choose an alternative decommissioning option at the actual time of decommissioning in accordance with its business needs, recognizing that it needs to assure the chosen option meets NRC requirements for decommissioning funding.

In order to estimate the costs associated with maintenance of the CPS site in SAFSTOR and the eventual decommissioning of the site, at the time of the estimate, CEG assumed 2035 as the first year that the U.S. Department of Energy (DOE) will begin removing spent nuclear fuel from nuclear power reactor sites. In accordance with the Nuclear Waste Policy Act (Reference 5.2), the Federal government has the responsibility to remove all spent fuel from CPS and other commercial nuclear power reactor sites. However, the DOE spent fuel and high-level waste management program is currently stalled. Given the status of the DOE program, CEG considered information made publicly available by DOE, the Government Accountability Office (GAO), the Blue Ribbon Commission on America's Nuclear Future, and the political environment surrounding this issue, and concluded that 2035 was the most likely timeframe for DOE to initiate removal of commercial nuclear fuel from reactor sites.

2.0 Spent Fuel Management Strategy

The NRC requires (as discussed in 10 CFR 50.54(bb)) that licensees establish a program "to manage and provide funding for the management of all irradiated fuel at the reactor following permanent cessation of operation of the reactor until title to the irradiated fuel and possession of the fuel is transferred to the Secretary of Energy for its ultimate disposal in a repository." Pending transfer of the fuel to the DOE [Secretary of Energy], CEG will store fuel on an interim basis in the spent fuel pool and/or the Independent Spent Fuel Storage Installation (ISFSI) located at the CPS site.

A licensed ISFSI is currently operational at CPS. The ISFSI facility will be expanded to accommodate the inventory of spent fuel in the spent fuel pool following the final reactor defueling. After the required cooling time, the spent fuel will be loaded in fuel storage canisters and moved to the ISFSI. Once the spent fuel pool is emptied of fuel, the facility will be placed in a SAFSTOR condition. The ISFSI will continue to operate until the transfer of spent fuel to the DOE is complete.

Assuming the DOE's generator allocation/receipt schedules are based upon the oldest fuel receiving the highest priority and that the DOE begins removing spent fuel from commercial facilities in 2035 with an annual capacity of 3,000 metric tons of uranium, spent fuel is projected to remain at the CPS site for approximately 17 years after the termination of operation (spent fuel is projected to be removed from the CPS site by the end of 2044). Any delay in transfer of fuel to DOE or decrease in the rate of acceptance will correspondingly prolong the transfer process and result in spent fuel remaining at the site longer than anticipated.

Attachment 2

Spent Fuel Management Plan for Clinton Power Station

Operation and maintenance costs for the storage facilities (ISFSI and spent fuel pool) are reflected in the CPS Decommissioning Cost Estimate (DCE) (Reference 5.1). The estimate includes the costs for staffing the facilities, maintenance of necessary operational requirements as well as security, insurance, and licensing fees. The estimate includes the costs to purchase, load, and transfer the fuel storage canisters to the ISFSI and to decommission the ISFSI. A discussion of site-specific considerations for the management of spent fuel at CPS is included in the DCE report.

When CPS terminates operations in 2027, CPS will continue to comply with existing NRC licensing requirements, including the operation and maintenance of the systems and structures needed to support continued operation of the CPS spent fuel pool and ISFSI, as necessary, under the decommissioning scenario ultimately selected. In addition, CPS will also comply with applicable license termination requirements in accordance with 10 CFR 50.82, "Termination of license," with respect to plant shutdown and post-shutdown activities, including seeking NRC approvals as appropriate for the continued storage of irradiated fuel until transfer of the fuel to the DOE is complete.

3.0 Cost Estimate and Funding for Spent Fuel Management

Total costs for spent fuel management under the SAFSTOR scenario will be approximately \$209.7 million (2021 dollars). Further breakdown is included in the DCE (Reference 5.1).

As of December 31, 2021, the CPS decommissioning trust fund balance was \$719.0 million. At this time, there are no annual contributions to the fund, and none are anticipated through the decommissioning period. To the extent that the trust fund balance exceeds costs required for radiological decommissioning, trust fund monies (subject to receipt of NRC approval of an exemption as discussed in Section 4), in conjunction with CEG operating revenues, will be used to pay for spent fuel management costs.

An additional potential source of funding for CPS spent fuel management costs is the Settlement Agreement between CEG and the DOE, under which the United States Government has agreed to reimburse CEG for costs incurred attributable to DOE's failure to meet its contractual obligations for the transfer of spent fuel from CPS and other CEG nuclear plants (Reference 5.3).

4.0 NRC Approvals

This SFMP contemplates potential withdrawals from the decommissioning trust for spent fuel management purposes. Prior to any such withdrawals, in accordance with 10 CFR 50.12, "Specific exemptions," CEG will make appropriate submittals seeking an exemption from the requirements of 10 CFR 50.82(a)(8)(i)(A) in order to use the decommissioning trust funds for spent fuel management expenses. CEG will monitor the funding level of the decommissioning fund to ensure that spent fuel management withdrawals will not inhibit the ability of CEG to complete radiological decommissioning.

Attachment 2

Spent Fuel Management Plan for Clinton Power Station

5.0 References

- 5.1 DECOM-2021-DCE-CPS, Revision 0, "2021 Decommissioning Cost Analysis Report Clinton Power Stations," March 2022
- 5.2 United States of America Public Law 97-425, "Nuclear Waste Policy Act of 1982," dated January 7, 1983
- 5.3 Settlement Agreement between the U.S. Department of Energy and Exelon Generation Company, LLC (including Commonwealth Edison Company and AmerGen Energy Company), signed and executed August 5, 2004, as amended by the First Addendum to the Settlement Agreement signed May 4, 2009, as amended by the Second Addendum to the Settlement Agreement signed August 18, 2019

Attachment 3

Decommissioning Cash Flow Analysis for Clinton Power Station (thousands of 2022 dollars)

Year	Radiological Decommissioning Cost	ISFSI Decommissioning Cost	Total Cost ^(a)	BOY Trust Fund Value	BOY Trust Fund Less Cost	Trust Fund Earnings ^(b)	EOY Trust Fund Value ^(a)
2025 ^{(c)(d)}	3,994	0	3,994	763,004	759,011	15,180	774,191
2026 ^(c)	5,606	0	5,606	774,191	768,585	15,372	783,957
2027	59,619	0	59,619	783,957	724,338	14,487	738,824
2028	61,279	0	61,279	738,824	677,546	13,551	691,097
2029	52,832	0	52,832	691,097	638,265	12,765	651,030
2030	48,965	0	48,965	651,030	602,065	12,041	614,106
2031	44,084	0	44,084	614,106	570,022	11,400	581,423
2032	24,450	0	24,450	581,423	556,973	11,139	568,112
2033	7,425	0	7,425	568,112	560,687	11,214	571,901
2034	6,695	0	6,695	571,901	565,206	11,304	576,510
2035	6,695	0	6,695	576,510	569,815	11,396	581,212
2036	6,713	0	6,713	581,212	574,498	11,490	585,988
2037	6,695	0	6,695	585,988	579,293	11,586	590,879
2038	6,695	0	6,695	590,879	584,184	11,684	595,868
2039	6,695	0	6,695	595,868	589,173	11,783	600,956
2040	6,713	0	6,713	600,956	594,243	11,885	606,128
2041	6,695	0	6,695	606,128	599,433	11,989	611,422
2042	6,695	0	6,695	611,422	604,727	12,095	616,821
2043	6,214	0	6,214	616,821	610,607	12,212	622,819
2044	6,073	0	6,073	622,819	616,746	12,335	629,081
2045	7,249	0	7,249	629,081	621,832	12,437	634,269
2046	7,249	0	7,249	634,269	627,019	12,540	639,560
2047	7,249	0	7,249	639,560	632,310	12,646	644,957
2048	7,269	0	7,269	644,957	637,688	12,754	650,441
2049	7,249	0	7,249	650,441	643,192	12,864	656,056
2050	7,249	0	7,249	656,056	648,807	12,976	661,783
2051	7,249	0	7,249	661,783	654,534	13,091	667,624
2052	7,269	0	7,269	667,624	660,355	13,207	673,562
2053	7,249	0	7,249	673,562	666,313	13,326	679,639
2054	7,249	0	7,249	679,639	672,390	13,448	685,838
2055	7,249	0	7,249	685,838	678,589	13,572	692,161
2056	7,269	0	7,269	692,161	684,892	13,698	698,589
2057	7,249	0	7,249	698,589	691,340	13,827	705,167
2058	7,249	0	7,249	705,167	697,918	13,958	711,876
2059	7,249	0	7,249	711,876	704,627	14,093	718,719
2060	7,269	0	7,269	718,719	711,450	14,229	725,679

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Decommissioning Cash Flow Analysis for Clinton Power Station (thousands of 2022 dollars)

Year	Radiological Decommissioning Cost	ISFSI Decommissioning Cost	Total Cost ^(a)	BOY Trust Fund Value	BOY Trust Fund Less Cost	Trust Fund Earnings ^(b)	EOY Trust Fund Value ^(a)
2061	7,249	0	7,249	725,679	718,430	14,369	732,799
2062	7,249	0	7,249	732,799	725,550	14,511	740,061
2063	7,249	0	7,249	740,061	732,811	14,656	747,468
2064	7,269	0	7,269	747,468	740,198	14,804	755,002
2065	7,249	0	7,249	755,002	747,753	14,955	762,708
2066	7,249	0	7,249	762,708	755,459	15,109	770,568
2067	7,249	0	7,249	770,568	763,319	15,266	778,585
2068	7,269	0	7,269	778,585	771,316	15,426	786,743
2069	7,249	0	7,249	786,743	779,493	15,590	795,083
2070	7,249	0	7,249	795,083	787,834	15,757	803,591
2071	7,249	0	7,249	803,591	796,342	15,927	812,268
2072	7,269	0	7,269	812,268	804,999	16,100	821,099
2073	7,249	0	7,249	821,099	813,850	16,277	830,127
2074	7,249	0	7,249	830,127	822,878	16,458	839,336
2075	7,249	0	7,249	839,336	832,086	16,642	848,728
2076	7,269	0	7,269	848,728	841,459	16,829	858,288
2077	7,249	0	7,249	858,288	851,039	17,021	868,060
2078	7,249	0	7,249	868,060	860,810	17,216	878,027
2079	7,249	0	7,249	878,027	870,777	17,416	888,193
2080	7,269	0	7,269	888,193	880,924	17,618	898,542
2081	38,335	0	38,335	898,542	860,207	17,204	877,412
2082	96,109	0	96,109	877,412	781,303	15,626	796,929
2083	108,272	0	108,272	796,929	688,657	13,773	702,430
2084	108,569	0	108,569	702,430	593,861	11,877	605,739
2085	112,182	2,744	114,925	605,739	490,813	9,816	500,629
2086	72,177	7,299	79,476	500,629	421,153	8,423	429,576
2087	8,391	0	8,391	429,576	421,186	8,424	429,609
Totals ^(a)	1,186,016	10,043	1,196,059				

(a) Cash flows may not add due to rounding

(b) A 2% real rate of return is used as allowed by 10 CFR 50.75(e)(1)(i)

(c) 2025 and 2026 costs are for decommissioning planning

(d) The 2025 BOY Trust Fund Value is the value of the decommissioning trust fund prior to the 2025 decommissioning planning expenses