



# System Analysis Support of Consent-Based Siting Efforts - 23400

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*Changing the World's Energy Future*

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## System Analysis Support of Consent-Based Siting Efforts - 23400

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### ABSTRACT

To better enable informed decision-making regarding the back end of the nuclear fuel cycle, the Integrated Waste Management (IWM) program within the U.S. Department of Energy, Office of Nuclear Energy (DOE-NE) has been sponsoring the development and application of system analysis tools capable of analyzing various system options for the management of spent nuclear fuel (SNF) and high-level radioactive waste. With these tools, integrated waste management system (IWMS) architecture analyses are being conducted to support the future deployment of a comprehensive nuclear waste management system that considers all major back-end aspects of the nuclear fuel cycle (i.e., transportation, storage, and disposal).<sup>a</sup> System analyses and assessments typically use these modeling and simulation tools to investigate things like the implications of changes in various assumptions and parameters such as acceptance rates, receipt logic, facility capacities and capabilities, use of standardized canisters, and different assumed system operation start dates. Some example system analysis results have been published previously.

With the passage of the consolidated appropriations acts for Fiscal Year 2021 [3] and for Fiscal Year 2022 [4], Congress provided funding and direction for the DOE to move forward under existing authority to identify a site for a federal interim storage facility using a consent-based approach. Consent-based siting is a phased, adaptive, and collaborative approach to siting a facility that focuses on the needs and concerns of people and communities. The approach will enable communities to participate in the siting process by working carefully through a series of phases and steps with the DOE (as the implementing organization). Each step and phase will help a community determine whether and how hosting a facility to manage SNF is aligned to the community's goals. By its nature, a consent-based siting process must be transparent, flexible, adaptive, and responsive to community concerns. Thus, the phases and steps are intended to serve as a guide, not a prescriptive set of instructions.

System analysis research analysts interface with the DOE consent-based siting program for a federal interim storage facility and can perform preliminary system analyses as requested to support various

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<sup>a</sup> This is a technical paper that does not take into account contractual limitations or obligations under the Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste (Standard Contract) (10 CFR Part 961). For example, under the provisions of the Standard Contract, spent nuclear fuel in multi-assembly canisters is not an acceptable waste form, absent a mutually agreed to contract amendment. To the extent discussions or recommendations in this paper conflict with the provisions of the Standard Contract, the Standard Contract governs the obligations of the parties, and this paper in no manner supersedes, overrides, or amends the Standard Contract. This paper reflects technical work which could support future decision making by the Department of Energy (DOE or Department). No inferences should be drawn from this paper regarding future actions by DOE, which are limited both by the terms of the Standard Contract and Congressional appropriations for the Department to fulfill its obligations under the Nuclear Waste Policy Act including licensing and construction of a spent nuclear fuel repository.

aspects of the consent-based siting team's work. This paper provides an overview of the IWM program's system analysis activities that support the ongoing consent-based siting process.

It is anticipated that decision-makers, planners, communities, and stakeholders may have questions during the consent-based siting process that are similar to questions that have been explored by system analysts previously regarding operation of a consolidated interim storage facility. Specifically, this paper discusses work that will inform consent-based siting efforts in the areas of community impacts, cost estimates, various SNF acceptance rates by a potential facility, potential consolidated interim storage facility (CISF) capacities and configurations, and the implications of a CISF on the overall waste management system. It is expected that system analysis will continue to be performed to support the consent-based siting process in the future.

## **INTRODUCTION**

To better enable informed decision-making regarding the back end of the nuclear fuel cycle, the Integrated Waste Management (IWM) program within the U.S. Department of Energy, Office of Nuclear Energy (DOE-NE) has been sponsoring the development and application of system analysis tools capable of analyzing various system options for the management of spent nuclear fuel (SNF) and high-level radioactive waste. With these tools, integrated waste management system (IWMS) architecture analyses are being conducted to support the future deployment of a comprehensive nuclear waste management system that considers all major back-end aspects of the nuclear fuel cycle (i.e., transportation, storage, and disposal). System analyses and assessments typically use these modeling and simulation tools to investigate things like the implications of changes in various assumptions and parameters such as acceptance rates, receipt logic, facility capacities and capabilities, use of standardized canisters, and different assumed system operation start dates. Some example system analysis results have been published previously [1, 2].

System analysis research analysts interface with the DOE consent-based siting program for a federal interim storage facility and can perform preliminary system analyses as requested to support various aspects of the consent-based siting team's work. The purpose of this paper is to provide an overview of the systems analysis modeling that will be used to help inform consent-based siting efforts. The goal of consent-based siting is to utilize an extensive public process to inform communities of the potential risks and benefits of hosting a consolidated interim storage facility (CISF). It is anticipated that potential host communities will want to know what a CISF will look like, what the human health risks (e.g., impact on cancer rates) and economic benefits (e.g., jobs creation) could be, and if there could be other environmental impacts (e.g., groundwater contamination). The potential host communities may use this information to determine if they are willing to grant their consent to host a CISF or not.

Systems analysis research and modeling is providing the foundation of this important information that will be given to potential host communities. The first step is to develop hypothetical CISF scenarios to model because no actual CISF proposals for a federal CISF are being made at this time. The next step is for the systems research team to deliver notional site layouts (e.g., number and types of buildings) to inform visual impact analyses. The systems analysts will also generate cost estimates for a CISF (i.e., direct costs for construction and operation), which will serve as the basis for modeling secondary socioeconomic benefits (e.g., the "multiplier effect" and increases to the tax base) and can also estimate the radiation dose for radiological and non-radiological workers to help with understanding the human health risks.

All of these modeling results will be portrayed to the public in a manner that is easy for them understand. To that end a Story Map is being developed to provide a useful online and interactive experience that will

include interactive maps, graphs, charts, and text boxes of the important information that communities will likely want to know when considering hosting a CISF.

## **CONSENT-BASED SITING AND SYSTEM ANALYSIS**

Congress passed the Consolidated Appropriations Act, 2021 [3] and Consolidated Appropriations Act, 2022 [4] which provides funding and direction for DOE to move forward under existing authority to identify a site for a federal interim storage facility using a consent-based approach. The approach will enable communities to participate in the siting process by carefully working with DOE (as the implementing organization) through a series of phases and steps.

It is anticipated that decision-makers, planners, communities, and stakeholders may have questions during the consent-based siting process that are similar to those previously explored by system analysts regarding operation of a consolidated interim storage facility. Systems analysts will support consent-based siting work, as needed, to help gauge community impacts, costs, SNF acceptance rates by potential facility, potential CISF capacities and configurations, the implications of a CISF on the overall IWMS, and potentially other items.

## **SYSTEM ANALYSIS INPUT TO GENERIC IMPACT ASSESSMENT**

During the early phases of the consent-based siting process, specific CISF features and candidate locations for possible CISF siting will be undetermined. Accordingly, the information shared with stakeholders during these early phases about the potential effects of CISF hosting will be based on the results of a generic impact assessment (GIA).

The GIA will be based on two generic scenarios for CISF design and operation and hypothetical and/or genericized locations. The scope of the GIA will include various analyses, and the one that this paper will focus on is quantitative analysis of socioeconomic effects, including jobs and income generated as a result of CISF construction and operation, potential effects on social services, and potential revenue for the local government. Additional attributes of the generic CISF scenarios were modeled to support the GIA analyses. These include the system costs and numbers of radiological and non-radiological workers by phase of activity. This paper will focus on how system costs affect socioeconomic factors.

System costs, including the direct costs to build, operate, and decommission generic CISFs, are needed for the socioeconomic modeling. These costs were modeled using the Next Generation System Analysis Model (NGSAM), an agent-based simulation of the storage, transportation, and disposal of SNF in the United States [5]. NGSAM is an agent-based, discrete event model that is written in Java and addresses all aspects of the nuclear waste management process: waste generation, onsite storage at various locations, centralized or regional interim storage, transportation, and ultimate disposal. The existing SNF inventory data for both assemblies and casks as recorded in the latest survey performed by the Energy Information Administration [6] were used. NGSAM uses the burnup, initial enrichment, reactor type, and calculated decay heat with cask-loading limits on these quantities to determine when the SNF can be shipped from reactor sites to a CISF or another destination. Future discharges were modeled using a fuel projection, which generally assumes that reactors receive a 20-year license extension (for a total of 60 years of operating life) and operate for the duration, unless an early shutdown is announced [7]. NGSAM models transportation by matching the designated transportation cask and storage cask types to corresponding canisters. Various certificates of compliance for regulatory heat limits are applied.

In this case, simulated rail consists (a “consist” is the group of rail vehicles which make up a train) were typically composed of seven casks on separate railcars. In this model, the CISF simply receives the casks

as they arrive from the reactor sites. The CISF in NGSAM is specified by the rate at which it accepts and ships SNF, as well as a maximum capacity. After the CISF hold period (the time between when shipments to the CISF stop and when shipments away from the CISF begin) has elapsed, the SNF is modeled as being shipped to a permanent repository for final disposition.

NGSAM's principal output projects how much SNF goes where and in which cask. For the CISF, the receipt rate and the ultimate size drive costs. Overall, unit costs are applied for each storage module, the site itself, and receipt and shipment equipment. Capital, decommissioning, fixed operating, and variable operating costs are applied to each component. Components are bought until they can handle the casks given by NGSAM (which also tightly corresponds to user input). The capacity is assumed to be built out until the capacity specified by NGSAM is reached.

The scenarios considered by the consent-based siting team are listed in Table I (Fig. 1 shows the acceptance or shipment rate away from the CISF by year for each of the scenarios). These scenarios were motivated by considerations of how communities might be impacted. The scenarios varied the CISF capacity, receipt rate, and storage time. "Large" refers to a maximum storage capacity of 70,000 metric tons of heavy metal (MTHM) abbreviated as 70k in the table. "Small" refers to a maximum storage capacity of 35k MTHM. The number after "Hold" refers to how long in years the hold period is without shipments, and "Higher Receipt" refers to scenarios with a receipt rate of 4,500 MTHM per year. This initial analysis does not include the decommissioning phase following the spent fuel drawdown phase for the facility. Additional scenarios can be considered in the future as the consent-based siting process proceeds.

TABLE I. Consent-based Siting Scenario Listing

Model Runs	Max Storage Capacity (MTHM)	Max Throughput (MTHM per Year)		Years by Phase				
		Receipt (IN)	Drawdown (OUT)	Total	Initial Construction	Receipt	Hold	Drawdown
LARGE Model Runs (70k Storage Capacity)								
Large Base Scenario	70k	3k	3k	80	5	25	25	25
Large Hold Zero	70k	3k	3k	55	5	25	0	25
Large Hold 10	70k	3k	3k	65	5	25	10	25
Large Higher Receipt	70k	4.5k	3k	73	5	18	25	25
SMALL Model Runs (35k storage capacity)								
Small Base Scenario	35k	1.5k	1.5k	80	5	25	25	25
Small Hold Zero	35k	1.5k	1.5k	55	5	25	0	25
Small Hold 10	35k	1.5k	1.5k	65	5	25	10	25
Sensitivity runs are in italics								

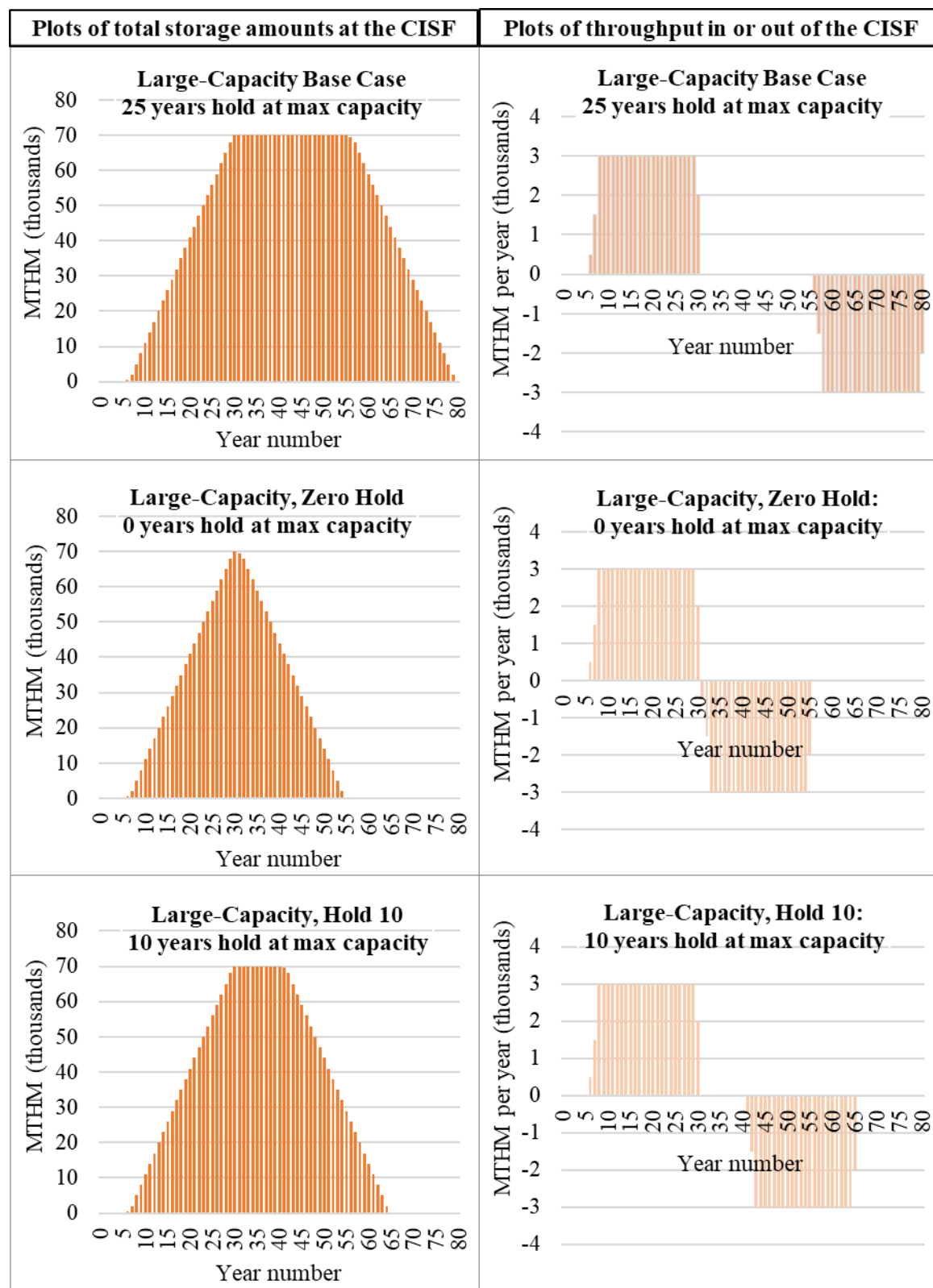


Fig. 1. Comparison of the Attributes for the Base Case and Sensitivity Analyses of the Large Capacity CISF Hold Phase Duration.



The python-based logistics and operations system (PLOTS) post-processing Python program parameterizes the CISF, breaking down costs along two dimensions. The first is whether each cost is associated with capital acquisition (buildings or overpacks) or additional operation costs associated with performing the mission of the CISF component.

The second dimension where the CISF cost is also broken down is comprised of various components: components to interface with transportation, components to provide storage, and components to transfer casks between overpacks. The component types are further broken down into horizontal and vertical variants. For a given scenario, only the required number of components is acquired.

The CISF costs were provided to the consent-based siting team in de-pivoted format so that they could drill down to examine the items they wanted. Fig. 2 below shows the current year costs of each scenario as a time series. The construction phase is clearly visible during the first 5-10 years, sometimes with a second spike if additional receipt facilities are built. A plateau around years 15 through 25 reflects storage being built out as casks are received. Finally, the storage (hold) and ship-out (drawdown) phases are low constant values in the range of tens of millions annually.

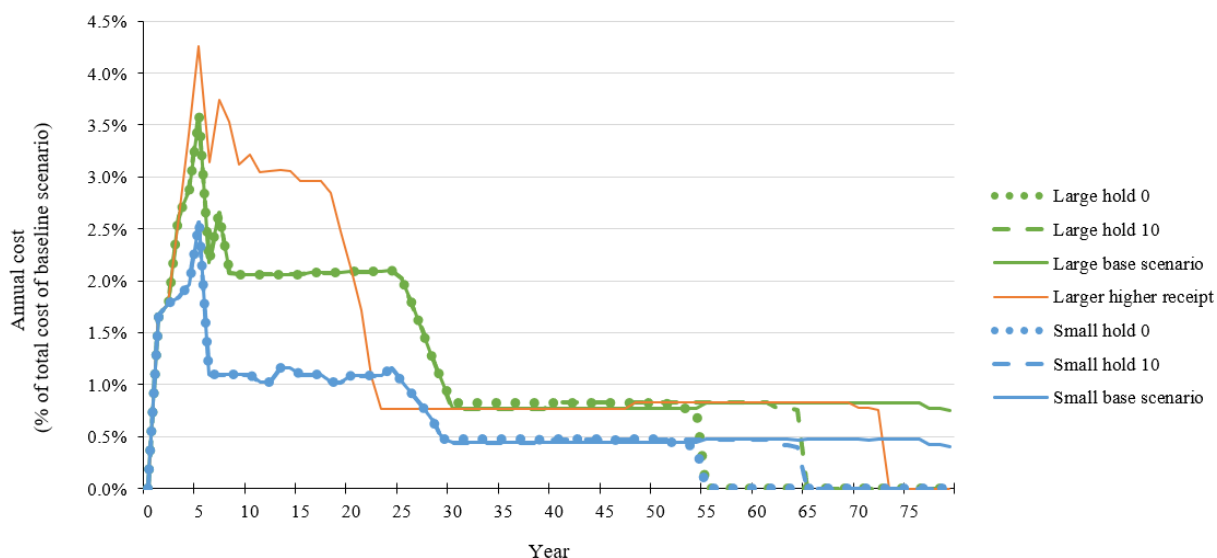


Fig. 2. Annual costs of scenarios with 5 years of smoothing applied to previous years for capital costs.

Note that large capital costs are ‘smoothed’ by evenly distributing capital costs over five years when reporting costs. Overall, fixed operating costs tend to dominate the CISF operation. For this initial analysis, the CISF receipt and shipment facilities were assumed to be kept in a standby mode without reduced staff. Subsequent analysis to examine the effect of placing the receipt/shipment facilities into a dormant, rather than standby, mode for the hold period and the cost reductions associated with reduced staff is an area for future investigation. The operating cost is largely related to staffing, while the initial capital spike is not related to a long-term labor force. The continued storage buildout does include more laborers in the host community. An example breakdown by cost category is shown in Fig. 3 below for the large CISF scenario with a 25-year hold time and a 4500 MTHM/yr receipt rate.

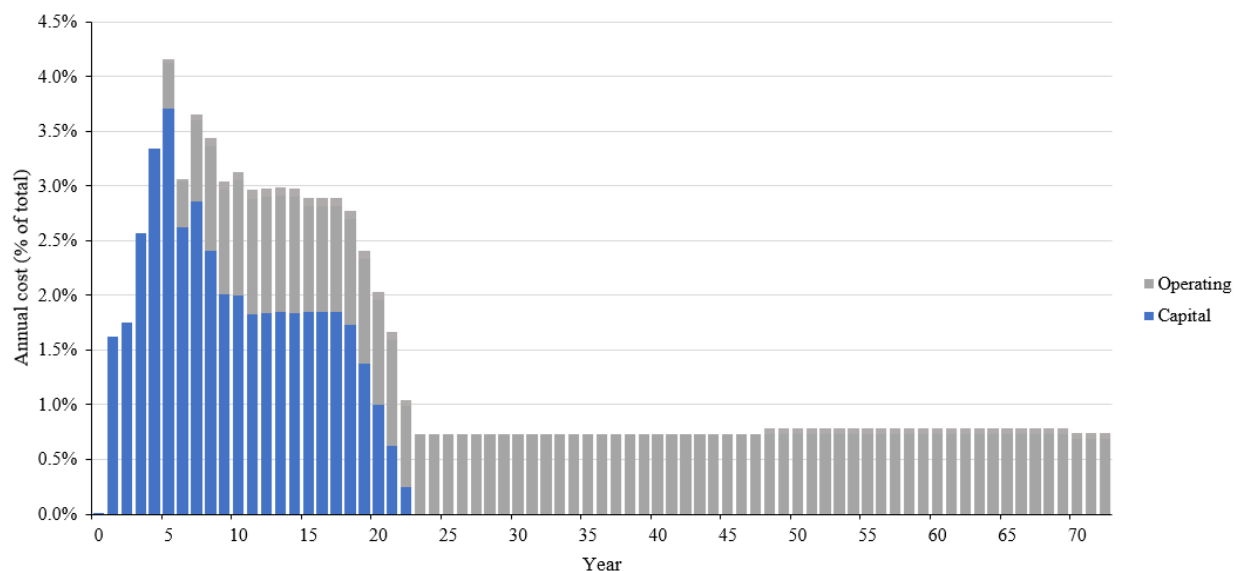


Fig. 3. Annual costs of Larger Higher Receipt scenario with 5 years of smoothing applied to previous years for capital costs.

The PLOTS cost model enabled consent-based siting investigators to visualize a detailed cost breakdown of the CISF to better understand the costs and impacts to communities.

## CONCLUSIONS

System analysis research analysts interface with the DOE consent-based siting program for a federal interim storage facility and can perform preliminary system analyses as requested to support various aspects of the consent-based siting team's work. This paper provided an overview of the IWM program's system analysis activities that support the ongoing consent-based siting process. Specifically, the results from NGSAM and the PLOTS cost model enabled consent-based siting team to visualize a cost breakdown of the CISF to better understand the costs and impacts to communities. It is expected that system analysis will continue to be refined and used to inform the consent-based siting effort.

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