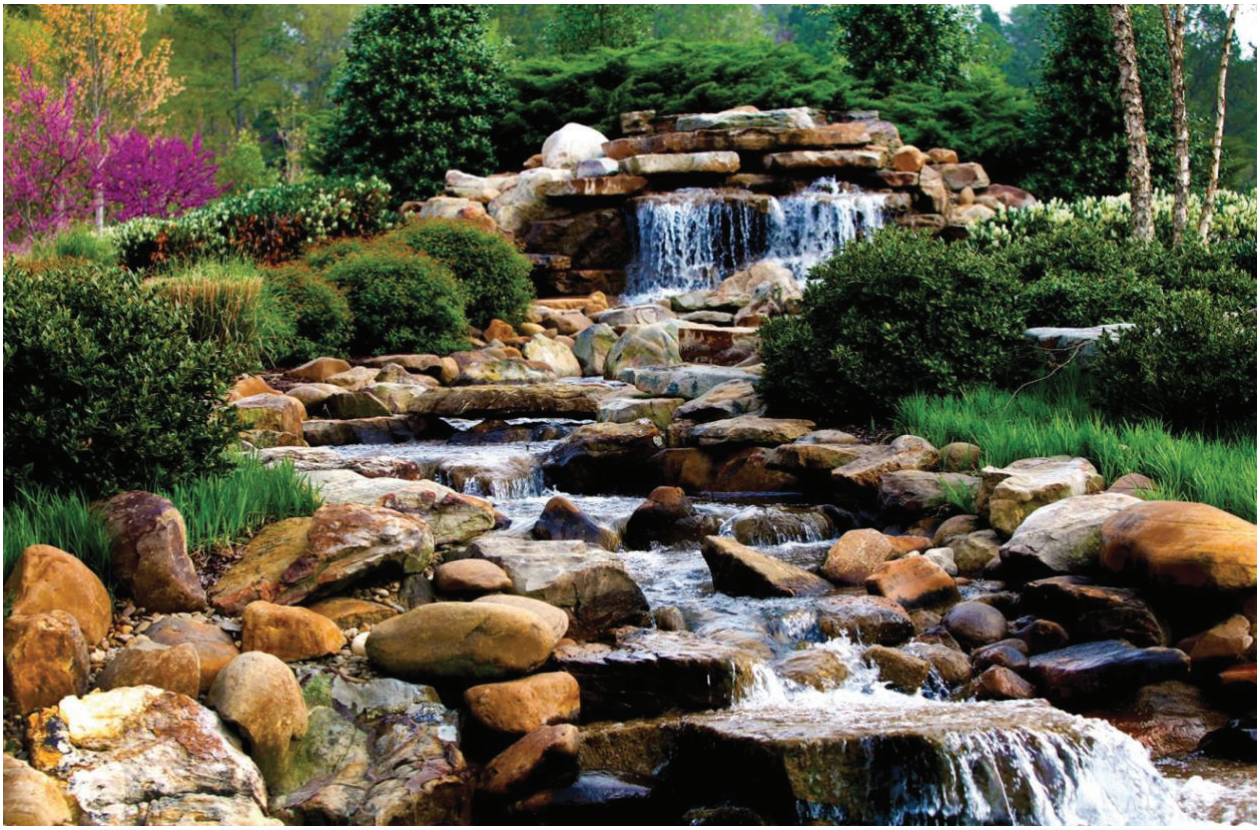
DOE/NRC CRITICALITY SAFETY FOR COMMERCIAL-SCALE HALEU FOR FUEL CYCLE AND TRANSPORTATION (DNCSH) PROJECT CHARTER

Version 1.4

12/10/2024



OAK RIDGE National Laboratory

U.S. DEPARTMENT OF ENERGY

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Nuclear Energy and Fuel Cycle Division

VERSION HISTORY

Version #	Implemented By	Revision Date	Approved By	Approval Date	Reason
1.0	W. Wieselquist	3/1/2023	D. Algama	3/2/2023	*Initial workshop meeting and requirements set.*
1.1	W. Wieselquist	11/30/2023	D. Algama	12/1/2023	*Draft charter for review.*
1.2	W. Wieselquist	12/15/2023	D. Algama	12/16/2023	*Concurrence received.*
1.3	W. Wieselquist	7/23/2024	D. Algama	7/24/2024	*Updated cost by FY table and revised timeline.*
1.4	W. Wieselquist	12/10/2024	D. Algama	12/11/2024	*Final technical edits, classification review, and export control review received.*

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1 INTRODUCTION

1.1 PURPOSE OF PROJECT CHARTER

The **D**OE/**N**RC **C**riticality **S**afety for Commercial-Scale High-Assay Low-Enriched Uranium **(H**ALEU) for Fuel Cycle and Transportation (DNCSH) Project Charter serves as the official top-level documentation and authorization for the DNCSH project. This charter is instrumental in providing guidance and a framework for the project's management from its initiation to conclusion. It records essential information, including project requirements, objectives, and resource allocations, which are crucial for obtaining decision-makers' approval and financial support. Furthermore, the charter acts as a comprehensive reference, detailing the project's intended goals, scope, and rationale, thereby facilitating informed decision-making and strategic planning. This document is primarily intended for the project's sponsors, leadership team, and members, ensuring alignment and clarity of purpose across all levels of project involvement.

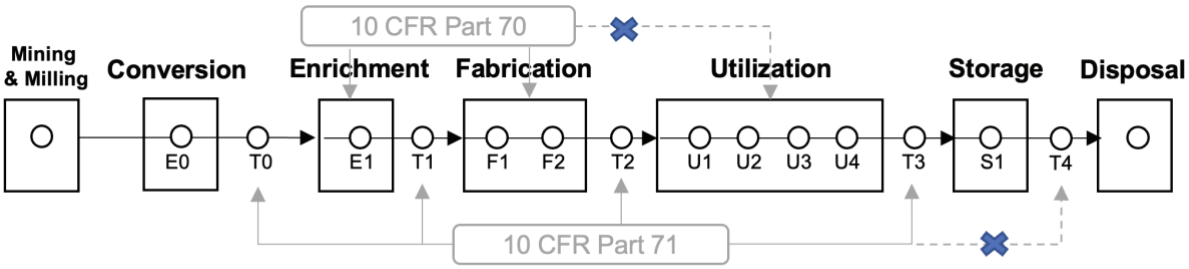
2 PROJECT OVERVIEW AND SCOPE

2.1 PROJECT OVERVIEW

The DNCSH initiative is a collaborative effort between the U.S. Department of Energy (DOE) and the U.S. Nuclear Regulatory Commission (NRC or "The Commission"), as mandated by the Energy Act of 2020 and the Inflation Reduction Act. Specifically, this initiative addresses Part (a)(2)(A) and Part (a)(2)(C)(ii) of Section 2001, "Advanced Nuclear Fuel Availability," of the Energy Act of 2020 (Public Law No. 116-260) and the Inflation Reduction Act (hereinafter referred to as "the Act"; H.R. 5376) to support the "availability of [HALEU] for civilian domestic research, development, demonstration, and commercial use."

This project is part of the overarching initiative to facilitate the availability of HALEU for a range of civilian applications, including research, development, and commercial purposes. The project's focus is on establishing new criticality benchmark data for commercial-scale nuclear energy; these data are crucial for the regulation and licensing of facilities handling special nuclear material and the certification of transportation packages for such materials, as outlined in the federal regulations. Additionally, this project will engage in activities that support the efficiency and robustness of licensing and criticality safety benchmark development processes—for example, in nuclear data improvements.

Figure 1 below provides an illustration of how the Act maps to a representative light water reactor (LWR) fuel cycle. The LWR fuel cycle is anticipated to be used as a reference in developing the other reactor-cycle-specific fuel cycles.



E0 – Conversion U3O8 to UF6
T0 – transportation of UF6 to enrichment facility
E1 – UF6 enrichment (<5w/o) and deconversion
T1 – transportation of UF6 to fuel fabrication facility
F1 – fabrication of UO2 fuel pellets
F2 – fabrication of LWR fuel assemblies
T2 – transportation of fresh fuel assemblies to the plant
U1 – fresh fuel staging and loading
U2 – power production
U3 – spent fuel pool/shuffle operations
U4 – on-site dry cask storage
T3 – transportation of spent fuel to off-site storage
S1 – off-site storage
T4 – transportation to disposition

Figure 1: Mapping of Act and Reference LWR Fuel Cycle (ML21088A047)

2.2 PROJECT SCOPE

For this effort, DOE and the NRC will first collaborate, using engineering judgment as appropriate, to develop reactor-design-driven HALEU fuel cycle application models using the SCALE code system. These application models will be presented to the community and industry as representative of **commercial-scale** transport and facility operations, which will eventually require licensing through the NRC. Next, these application models along with engineering judgement will be used to assess gaps in nuclear data and critical benchmarks for these specific systems. Finally, these data will be used to prioritize and rank proposals to perform new critical benchmarks. The bulk of project funds will be put toward funding the design, execution, and documentation of new benchmarks, targeting inclusion in the *International Criticality Safety Benchmark Evaluation Project Handbook* (ICSBEP Handbook), which is relied upon by industry and the NRC as the primary source of high-quality criticality safety benchmarks.

The work performed in this project is intended to produce publicly available data, methods, and evaluations to support both NRC regulatory activities and licensees. The NRC is anticipated to benefit through information that allows for updated regulations and guidance. Licensees are anticipated to benefit through information that enables updates, development, and higher quality and confidence in their licensing submissions.

3 JUSTIFICATION

3.1 BUSINESS NEED

Demand for a fuel enrichment range known as HALEU is rapidly increasing, with potential on the horizon for both new, advanced power reactors and performance enhancements to existing commercial power reactors. The HALEU Availability Program (HAP) is addressing the lack of U.S. infrastructure necessary for a commercial-scale enrichment operation that supplies this demand. However, there is an important additional parallel consideration for a timely transition to HALEU-based fuel cycles: the U.S. NRC must have the data necessary to evaluate the safety and efficiency at all stages of the fuel cycle, including transportation, utilization, and long-term storage. A significant component of those data is criticality benchmarks that are relevant for the specific proposed fuel forms, geometries, neutron absorbers, moderators for facility operations, and transportation at commercial scale. The commercial-scale component is important, as it is currently possible to produce, transport, and store fissile material at any enrichment, in any fuel form, in small quantities. The economic viability of HALEU-based fuel cycles depends on the ability to safely scale-up the quantity through new transportation and storage packages for these specific types of fuel.

However, the national capacity to produce high-quality criticality benchmarks according to the internationally agreed upon standards of the ICSBEP is limited. Within the U.S., benchmarks are designed, executed, and documented mainly under the Nuclear Criticality Safety Program (NCSP), with 1–3 critical benchmarks produced each year at two main facilities at Sandia National Laboratory (SNL) and the National Criticality Experiments Research Center (NCERC). The estimated cost of a single high-quality benchmark is $1–2M. DOE has funded ten advanced reactor designs through Advanced Reactor Demonstration Program (ARDP) awards. The congressional mandate applies to both front-end and back-end stages of the fuel cycle for transportation and the back-end stage for facility considerations. Considering there will be some overlap in designs, this still leads us to a rough estimate of 10–40 new critical benchmarks that could be needed to support all new reactors at all relevant fuel cycle stages during which criticality safety is a concern. This number of benchmarks may still fall short of providing the desired 10–20 applicable benchmarks for any application case.

With a target date for all funds to be committed by end of Fiscal Year (FY) 2026, it is likely that the SNL and NCERC facilities cannot be solely responsible for all benchmarks. Thus, there is an additional need within this project to be creative and flexible and use alternative resources such as university reactors and global facilities. Although funds will be obligated before September 2026 to meet the guidance in the Act, some projects are expected to extend into 2027.

3.2 RELATION TO HALEU PROGRAM MISSION

Per DOE HALEU Consortium program website:

"The U.S. Department of Energy (DOE) established the High-Assay, Low-Enriched Uranium (HALEU) Consortium to help inform activities carried out by the Department to secure a domestic supply of HALEU. Section 2001 of the Energy Act of 2020 directs the Secretary of Energy to establish and carry out, through the Department's Office of Nuclear Energy (NE), the HALEU Availability Program (referred to as the Program), including establishing the HALEU Consortium.

Currently, there is a very limited domestic capacity to provide HALEU from either DOE or commercial sources. This presents a significant obstacle to the development and deployment of advanced reactors and increases the risk of private investment to develop an assured supply of HALEU or to support the infrastructure required to produce it."

This HALEU fuel planned for advanced reactors will create a paradigm shift in the movement of fissile forms around the country. The different forms and enrichments of fuel planned for advanced reactors may have different neutronic characteristics that need to be understood. The criticality safety community relies on experimental validation for assurance of subcritical conditions. Current experimental validations are primarily limited to historical weapons production efforts and the commercial LWR fleet. Not only is there a need for validation of fuel characteristics in reactor operations, but the validation need for advanced reactor fuel must expand to support criticality safety under normal and credible abnormal conditions for processing of these fuels, as well as for the safe transport of the fuels under normal conditions of transport and hypothetical accident conditions.

The DOE NE Strategic Vision Plan published in January 2021 has five strategic goals. The vision of the strategic plan is a thriving U.S. nuclear energy sector delivering clean energy and economic opportunities, and the mission is to advance nuclear energy science and technology to meet U.S. energy, environmental, and economic needs. The third and fourth goals of this plan are as follows:

"Strategic Goal 3 – Develop advanced nuclear fuel cycles."
"Strategic Goal 4 – Maintain U.S. leadership in nuclear energy technology."

In support of Goal 3, DOE NE cites the following objective:

"Objective 1: Address gaps in the domestic nuclear fuel supply chain."

To support Goal 4, DOE NE cites the following objective:

"Objective 2: Maintain world-class research and development capabilities."

While the DOE HALEU Program Mission strategic goal is to advance nuclear fuel cycles with U.S. technologies, the NRC requires that criticality safety is demonstrated within a submitted license application. Criticality safety analyses in these applications are required to meet the American National Standard Institute (ANSI)/American Nuclear Society

(ANS) 8.1 Standard, endorsed by the NRC (Regulatory Guide 3.71, Rev. 3, ADAMS Reference ML18169A258), where: "Before a new operation with fissionable material is begun, or before an existing operation is changed, it shall be determined that the entire process will be subcritical under both normal and credible abnormal conditions." Additionally, any calculational method used to determine criticality safety is required by ANSI/ANS 8.1 to be validated: "Validation shall be performed by comparison to critical and exponential experiments, and the area of applicability for the validation should be established form this comparison." For applicants to demonstrate criticality safety, the methods are validated by like-kind critical experiments. These experiments are used to determine the adequacy of the methods and nuclear data used in the criticality safety analysis and determine penalties needed to address methods and data uncertainties. For advancing HALEU fuel cycles in the United States, critical experiments are needed to validate the methods and nuclear data used for criticality safety. Further, designers require data to support both efficient designs and confidence in operations.

This project is aligned with and leverages work already performed as part of the NRC Non-Light Water Reactor (Non-LWR) Vision and Strategy for simulation code preparedness, which includes developing models, demonstrations, and reference nuclide inventory. This existing work may be especially useful for back-end validation gap analyses.

4 CAPABILITY GAP AND APPROACH

4.1 CAPABILITY GAP

Effort is needed to develop better estimates for needs and priorities, with comprehensive consideration of new criticality benchmarks potentially from

1. historical or recent experiments that never had the funding to become proper ICSBEP benchmarks,
2. new benchmarks at existing U.S. facilities (Sandia/NCERC),
3. new benchmarks at other facilities (e.g., university reactors, international facilities) with higher (but well-qualified) uncertainty,
4. and new benchmarks at new or enhanced facilities (e.g., Horizontal Split Table and/or expansion of capabilities at existing critical facilities.)

4.2 APPROACH TOWARDS BENCHMARK

One potential approach is to simply reprioritize or synergize with the NCSP critical benchmarks. However, NCSP supports several mission needs with competing prioritizations. Even if we could prioritize a few benchmarks per year for this HALEU fuel cycle project (which represents 33% to 100% of total current capacity for new benchmark creation in one year), this would result in fewer than 10 new benchmarks by end of FY 2026, which falls far short of the estimated 10–40 that could be important to the NRC and its licensees and applicants. For this reason, we must immediately consider expansion of existing capabilities. Another approach is to become familiar with existing tests planned

and already executed, both in the U.S. and abroad, to understand how additional testing, characterization, etc. may be included that would support DNCSH project needs.

4.3 HIGH-LEVEL REQUIREMENTS

The following table presents the requirements that the project's product, service, or result must meet in order for the project objectives to be satisfied.

Req. #	Requirement Description
1	Make available new benchmark data and methods for use by industry in their license applications to the NRC.
2	Make available new benchmark data and methods for use by the NRC in their review of license applications.

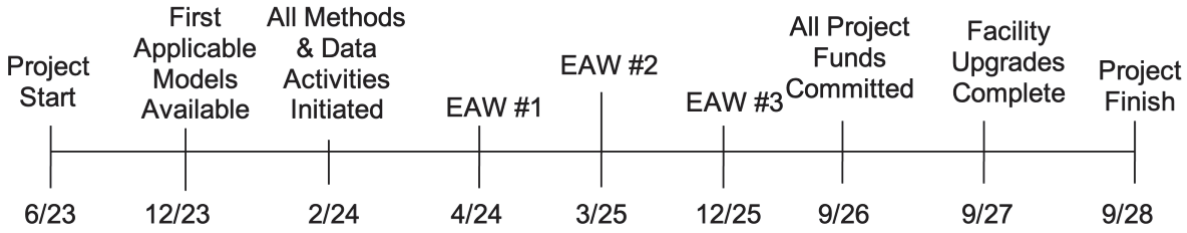
4.4 MAJOR DELIVERABLES

The following table presents the major deliverables that the project's product, service, or result must meet in order for the project objectives to be satisfied.

Major Deliverable	Deliverable Description
New nuclear data	New or improved nuclear data including uncertainty estimates, required for robust benchmark applicability analysis.
New methods	New or improved methods for validation basis assessment and benchmark development.
New criticality benchmarks	The creation of roughly 10–40 new benchmarks, initially available in draft form included in the SCALE validation basis, later to appear in the ICSBEP Handbook.
New capabilities at US facilities	Enhancement of US capabilities to produce benchmarks relevant to the project.

5 PROJECT DURATION

5.1 ESTIMATED TIMELINE



5.2 HIGH-LEVEL MILESTONES

The table below lists the high-level milestones of the portfolio and their estimated completion timeframe.

Key Milestones	Estimated Completion Date
*HALEU Project Start**	*06/05/23*
First set of application models available	*12/21/23*
All methods and nuclear data activities initiated	*02/29/24*
Experiments and Analyses (EAW) Call #1 Issued	*04/26/24*
EAW Call #2 Issued	*03/30/25*
EAW Call #3 Issued	*12/30/25*
All project funds committed	*09/30/26*
Final facility updates (if any) complete	*09/30/27*
HALEU Project Finish	*09/30/28*

*Project officially commenced when funding was received.

6 KEY ASSUMPTIONS, CONSTRAINTS, AND RISKS

6.1 KEY ASSUMPTIONS

1. ORNL will have oversight of the project and will have the ability to administer any funds associated with the effort to be allocated. Project activities, status, and their completion will be captured in the Project Management Plan.
2. Funds will be available to ORNL when necessary for scope execution.
3. Technical expertise of staff and availability are sufficient for project needs.
4. Critical personnel responsible for efforts related to the project are available.
5. Critical benchmarking facilities are available for use when needed.
6. Any increase in maintenance costs to facilities as a result of increased capacity is not the responsibility of this program.
7. Any procured material or benchmarking will require transfer of ownership to the facility using it upon project completion. An exception to this assumption may be fuel acquired from the HAP, which may need to be returned.

8. As part of the HAP, HALEU fuel will be available for use in research efforts.
9. Current project personnel will be available and actively involved for the duration of the project.
10. Where appropriate, computational models can be created that inform benchmark needs.

6.2 CONSTRAINTS

1. All project funds must be obligated no later than September 2026.
2. Critical benchmark capacity in the United States is limited. Facilities necessary are already in use by other entities/owners, so available time is limited.
3. The capacity of HALEU fuel availability is limited.

6.3 RISKS

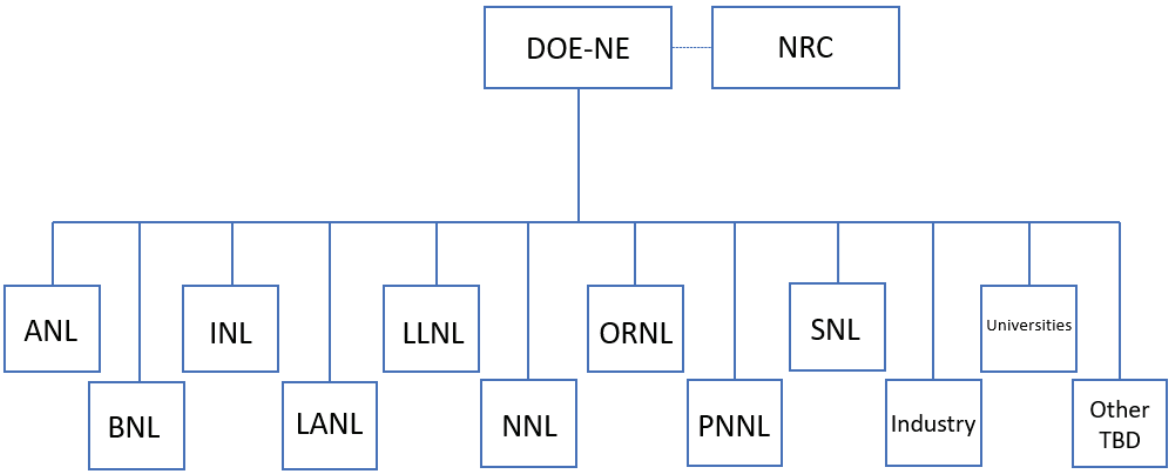
Risk	Mitigation
DOE funding profile inadequate to meet the project's needs.	The project team will maintain up-to-date, forward-looking planning and cost estimates.
The project is impacted by unexpectedly high escalation rates.	The project will maintain a reasonable level of contingency in a management reserve account in order to cover higher-than-expected escalation.
DOE doesn't fund the project.	DOE doesn't meet its goal of addressing gaps in the domestic nuclear fuel supply chain, developing advanced nuclear fuel cycles, or maintaining U.S. leadership in nuclear energy technology.
Technical readiness level of staff providing effort is not up to the standard level required for this effort.	Utilize subcontracts when appropriate to obtain needed expertise.
The production capacity of HALEU fuel is limited, and material needed for experiments is unavailable.	Project is an active participant in the HAP and is expected to have a natural priority for the fuel's usage, as without appropriate benchmarks in place, operating reactors cannot use HALEU fuel. Furthermore, alternative fuel sourcing will be investigated if needed.
We cannot commit the entirety of the project's funding by September 2026.	The project team will proactively seek a mixed portfolio of creating new benchmarks and promoting reevaluation of recent measurements that could be promoted to benchmarks, and also executing many tasks in parallel.
Parallel activities don't allow for learning from past activities.	Publications and forums for information exchange will be utilized.
Loss of key project personnel.	Proactively seek to ensure that key and critical

Risk	Mitigation
	project positions are maintained.
Computational models for benchmark needs are not adequate or timely.	Tightly manage schedules and require periodic presentations of progress. Furthermore, where appropriate, engineering judgement, public feedback from workshops, etc. will be used in addition to modeling evaluations to understand benchmark needs.
Dedicated critical facilities with the ability to generate benchmark quality data are limited to two locations in the U.S.: LANL/NCERC and Sandia. Enhancing existing capabilities, including developing an additional capability in the form of a flexible horizontal split table, is challenging.	Continued communication and collaboration with laboratories, the NCSP, other federal programs, and upper management at DOE will be maintained.

7 PROJECT ORGANIZATION AND MANAGEMENT

7.1 ORGANIZATIONAL CHART

ORNL will serve as the lead institution, overseeing funds distributions and the execution of the full scope of work. While the participating institutions will likely vary as decisions are yet to be finalized about where certain pieces of the scope will be executed, Sandia, INL, and LANL will be part of the project collaboration.



7.2 PORTFOLIO APPROACH

As currently planned, the HALEU project consists of 9 areas of scope: 1) management and stakeholder engagement, 2) quality assurance, 3) surveys and summaries, 4) facility creation, 5) simulation model development, 6) critical benchmark execution, 7) nuclear data enhancement, 8) simulation methods improvements, and 9) validation basis improvement. The institutions that comprise the HALEU project collaboration will execute the scope of work.

Although there are some interdependences within the scope, to a large degree, each of these areas of scope will be executed independently. Therefore, the project will be managed as a portfolio of projects. Each institution responsible for executing a piece of the project scope will plan, estimate, manage, and report their scope as part of the portfolio. The HALEU project portfolio to be managed at ORNL will contain the full scope of work.

7.3 ROLES AND RESPONSIBILITIES

This section describes the known key roles supporting the project. As EAWs are issued and awarded, additional specific key contacts will become available and added.

Organization	Project Role	Project Responsibilities
DOE-NE	Project Sponsor	Person responsible for acting as the project's champion and providing direction and support to the project. This person approves requests for funding, approves the project scope represented in this document, and sets the priority of the project relative to other projects in his/her area of responsibility.
DOE-NE	Sponsor Contracting Officer's Representative	DOE employee who provides the contracting mechanism for the Experiment and Analysis Work Packages Opportunity Announcements and oversight of same.
DOE-NE	Sponsor Project Manager	DOE employee who provides the interface between the National Technical Director and the Project Sponsor. Additionally, they will serve as the single focal point of contact for the National Technical Director.
DOE-NE	Advisor	Serve as representative for the DOE HALEU Consortium.
NRC	Collaborating Organization Interface	NRC employee who provides the interface between the National Technical Director and the main collaborating organization. Additionally, they will serve as the single focal point of contact

Organization	Project Role	Project Responsibilities
		for the National Technical Director.
ORNL	Project/Portfolio Oversight	ORNL will serve as the lead institution and will have oversight over the full scope of work executed as part of the project. As the lead institution working with DOE, ORNL will coordinate, approve, and oversee all budget distributions within the project collaboration.
ORNL	National Technical Director	The National Technical Director will be responsible for coordinating with all officials on projects for which contract support is contemplated. The Director is responsible for technical monitoring and evaluation of the collaborating institutions performance after funding award.
ORNL	Project/Portfolio Manager	The Project Manager will perform the day-to-day management of the project and has specific accountability for managing the project within the approved constraints of scope, quality, time, and cost, to deliver the specified requirements, deliverables, and sponsor satisfaction.
ORNL	Portfolio Scope Owner	Control Account Manager for the Quality Assurance Area.
ORNL	Portfolio Scope Owner	Control Account Manager for the Surveys and Summaries Area.
LANL	Portfolio Scope Owner	Control Account Manager for the Facility Enhancement Area.
NRC	Portfolio Scope Owner	Control Account Manager for the Reference Application Model Development Area.
LLNL	Portfolio Scope Owner	Control Account Manager for the Criticality Benchmark Execution Area.
ORNL	Portfolio Scope Owner	Control Account Manager for the Nuclear Data Enhancement Area.
ORNL	Portfolio Scope Owner	Control Account Manager for the Simulation Methods Improvements Area.
ORNL	Portfolio Scope Owner	Control Account Manager for the Validation Basis Improvement Area.

7.4 STAKEHOLDERS (INTERNAL AND EXTERNAL)

Stakeholders include DOE, the NRC, the national laboratory system, universities, and industry.

7.5 MEMORANDUMS OF UNDERSTANDING

A memorandum of understanding (MOU) is a formal, mutual agreement that outlines plans for a common line of action between two or more parties. MOUs will be used to define the common lines of action and high-level expectations between the institutions collaborating in support of the HALEU project.

MOUs are usually not legally binding and are less formal documents than a more-binding contract. All participating institutions will be expected to sign MOUs. MOUs will be generated by the lead institution, working in cooperation with the participating institutions.

8 PROJECT CHARTER APPROVAL

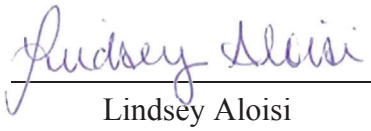
The undersigned acknowledge they have reviewed the project charter and authorize and fund the HALEU project. Changes to this project charter will be coordinated with and approved by the undersigned or their designated representatives.

Signature:	Bill McCaughey	Date:	12.18.2024
Print Name:	Bill McCaughey		
Title:	Acting Director, NE-41		
Role:	Acting Director-NE41		

Signature:	Don R. Algama	Date:	12.17.2024
Print Name:	Don Algama		
Title:	Nuclear Engineer, U.S. DOE		
Role:	Sponsor Project Manager		

Signature:	Andrew B. Barto	Date:	12.17.2024
Print Name:	Andrew Barto		
Title:	Senior Nuclear Engineer, U.S. NRC		
Role:	Collaborating Agency Interface		

Signature:		Date:	12.17.2024
Print Name:	Will Wieselquist		

Title:	Senior R&D Staff, ORNL
Role:	National Technical Director
Signature:	 Date: 12.17.2024
Print Name:	Lindsey Aloisi
Title:	NRC Business Operations Manager, ORNL
Role:	Project Manager

APPENDIX A: REFERENCES

The following table summarizes the documents referenced in this document.

Document Name and Version	Description	Location
Advanced Nuclear Fuel Availability Section of the Energy Act of 2020	Law allocating funding for efforts associated with advanced nuclear fuel availability.	Text - H.R.133 - 116th Congress (2019-2020): Consolidated Appropriations Act, 2021 | Congress.gov | Library of Congress
Inflation Reduction Act	Congressional bill allocating specific funding for new criticality benchmarks.	BILLS-117hr5376enr.pdf (congress.gov)
NRC/DOE Memorandum of Understanding	A document outlining the collaboration between the NRC and DOE in regard to enabling advanced fuels and fuel cycle applications.	ML22132A082
NRC Regulation Part 70	Portion of the NRC's regulations for domestic licensing of special nuclear material.	Part 70
NRC Regulation Part 71	Portion of the NRC's regulations for packaging and transportation of radioactive material.	Part 71
DOE/NE Strategic Vision Plan, 01/08/21	DOE-NE's strategic planning document including goals for reducing carbon emissions by 2030.	DOE-NE Strategic Vision - 01.08.2021.pdf (energy.gov)