ORNL/TM-2024/3335

Participation in and Assessment of the First DNCSH Public Workshop



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March 2024

OAK RIDGE National Laboratory

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ORNL/TM-2024/3335

Nuclear Energy and Fuel Cycle Division

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managed by
UT-BATTELLE LLC
for the
US DEPARTMENT OF ENERGY
under contract DE-AC05-00OR22725

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1. INTRODUCTION

High-assay low-enriched uranium (HALEU) fuel, describing a range of low-enriched uranium (LEU) fuel spanning 5–20 wt% ^{235}U, enables higher energy densities in reactors when compared to those of typical light water reactor (LWR) fuels enriched to 3–5 wt% ^{235}U. This can mean smaller designs, longer operating cycles, and increased efficiency, thereby improving the economics of nuclear power. Increasing industry interest in HALEU fuel for both advanced reactor design and in the existing LWR fleet has spurred government initiative to support US infrastructure for the integration of HALEU fuel into the US nuclear fuel cycle. This will necessitate improvements in enrichment, manufacturing, transport, and storage capabilities, all of which depend upon establishing appropriate safety limits through US Nuclear Regulatory Commission (NRC) regulations that facilitate commercial-scale operations. To support infrastructure development for HALEU fuel, the US Department of Energy (DOE) created the HALEU Availability Program (HAP), with initial funding sourced through the Inflation Reduction Act of 2022 (H.R. 5376) [1]. One element of the HAP is the DOE/NRC Criticality Safety for Commercial-Scale HALEU Fuel Cycle and Transportation (DNCSH) project, which specifically supports the NRC in reducing the uncertainty associated with approving commercial-scale facility and transportation operations for upcoming traditional and advanced industry applications of HALEU fuel. This project will survey the existing capabilities and emerging needs of the nuclear fuel cycle, as it pertains to improvements in existing experimental facilities, critical benchmark execution, nuclear data enhancement, simulation methods improvements, application model development, and validation basis improvement to support commercial-scale HALEU implementation.

To support the DNCSH project, a workshop was hosted by the NRC to inform stakeholders on the current DOE/NRC understanding of gaps in validation and nuclear data for the HALEU fuel cycle. Moreover, the workshop gathered feedback to inform the first call for benchmark proposals. This workshop took place on February 29, 2024, from 11:00 AM to 2:15 PM. The meeting, known as the *Workshop on Collaboration Between the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission for Development of Criticality Safety Benchmarking Data for HALEU Fuel Cycle and Transportation*, was open to the public and was attended by industry, DOE, NRC, and national laboratory stakeholders. A list of registrants can be found in APPENDIX A, Table A-1. A total of 223 participants joined the meeting, which was hosted online via Microsoft Teams as well as in person, and the slides from the meeting were uploaded online through the NRC's Agencywide Documents Access and Management System (ADAMS) [2]. The agenda of the meeting is provided in Figure 1-1. With a variety of attendees and presentations discussing the goals of the DNCSH project, the intent was to effectively engage the nuclear industry and regulators such that project funds can be appropriately directed to areas of the greatest need and interest. The scope of discussion was driven by an initial project report titled "Current State of Benchmark Applicability for Commercial-Scale HALEU Fuel Transport," which provides an overview of upcoming HALEU advanced reactor fuel types in the Advanced Reactor Demonstration Program (ARDP), transportation packages licensed for HALEU transport, potentially applicable critical benchmark experiments, and potentially suitable critical experiment facilities for future studies, among other related topics [3].

This report presents the feedback received from and information about participation in the workshop. All data presented represent voluntarily self-reported identification and opinions by workshop and survey

respondents and are assumed to be as accurate as practically reasonable. The results of the discussions during the workshop and survey responses received thereafter aim to direct attention to areas of specific interest by industry, as well as gauge the feedback of the work performed at this time by the DNCSH project.

Time	Topic	Speaker
11 - 11:02 a.m.	Welcome/Housekeeping	Mr. Andrew Barto, NRC
11:02 - 11:05 a.m.	Workshop Theme and Intro	Dr. William Wieselquist
11:05 - 11:15 a.m.	HALEU Availability Program	Mr. William McCaughey, Director, Advanced Fuels Technologies, DOE-NE
11:15 - 11:25 a.m.	Project Background	Mr. Don Algama, DOE-NE
11:25 - 11:35 a.m.	Project Goals	Mr. Andrew Barto, NRC
11:35 a.m. – 12:35 p.m.	Discussion of Considerations for HALEU-Based Fuel Cycle Validation Basis Assessment and Benchmark Prioritization, Including: Current HALEU-Based Reactor Landscape and Transportation Packages Current Nuclear Data Gaps (e.g. TSL Uncertainty)	Dr. William B.J. Marshall Dr. Iyad Al-Qasir Dr. Mathieu Dupont Dr. Lisa Fassino
12:35 - 12:50 p.m.	Open Discussion	Audience Questions
12:50 – 1:20 p.m.	Background on Validation Methods and the Need for Application Models	Dr. William B.J. Marshall Mr. Alex Shaw
1:20 – 1:50 p.m.	Presentation of Recently Developed Criticality Safety Application Models	Dr. William B.J. Marshall Mr. Alex Shaw Dr. Veronica Karriem
1:50 – 2:15 p.m.	Open Discussion	Audience Questions
2:15 p.m.	Concluding Remarks	Dr. William Wieselquist
	Adjourn	Ms. Lindsey Aloisi

Figure 1-1. DNCSH February 2024 workshop agenda

The report is structured chronologically. Section 2 presents the interest of the community given upon registration. Section 3 presents the recorded participation of the community during the workshop, and the key areas of discussion received from the public and industry are transcribed; any remaining concerns or points of discussion are also addressed in this section. Section 0 summarizes the feedback of the audience following the workshop, including a rating for event mission efficacy and their topics of interest for the future.

2. PRE-WORKSHOP INTEREST AND SURVEY

The workshop registration link was valid until the day before the workshop, and the page included a form with several questions regarding registrant info with an optional open-ended question regarding what topics they would like to have seen addressed during the workshop. Registrant name and affiliation was collected, and it is summarized in Table A-1 of APPENDIX A. The open-ended question was worded as follows:

Are there any specific topics that you would like to hear about or discuss during the workshop?

The complete list of responses is given in Table A-2 of APPENDIX A, and they can generally be categorized into the following topics relevant to the workshop:

1. Benchmark and Industry Needs:
   Responses related to interest in benchmark execution as well as industry plans
2. Transport and Processes:
   Responses related to interest in safety analyses of transport and process conditions
3. Data, Methods, and Analysis:
   Responses related to criticality safety analysis methods, validation, and nuclear data
4. Regulation:
   Responses related to interest in HALEU and transport regulation status and efforts
5. Project Logistics:
   Responses related to project management, funding, and allowed participants

These are broad categories with some overlap, and several responses do not fall into these categories, as they are considered out-of-scope. The most significant shared interest and desired outcome of the workshop was to understand industry plans for HALEU transport and how the project can be leveraged to support industry in their analysis and benchmark needs. The breakdown of response categories is illustrated in Figure 2-1.

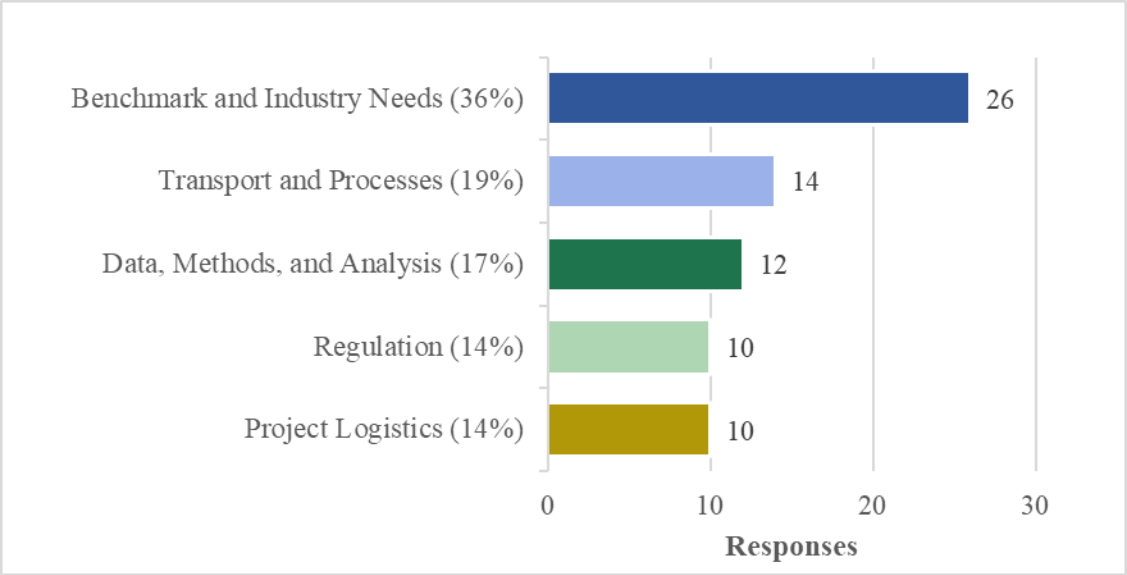


Figure 2-1. Categorization of pre-workshop survey results

More specifically, the initial survey responses within the project scope could largely be condensed into the following questions or interests:

1. Requests for benchmarks and industry information in support of direct oxide electroreduction; gas-cooled reactors; lithium and chlorine; spent fuel; and tri-structural isotropic (TRISO) fuel.
2. Is there an industry consensus to be made on HALEU transportation vessel size?
3. What are considered high-priority materials and fuel forms for benchmarks?
4. Are there known or suspected nuclear data shortfalls?
5. Who can participate in funding opportunities, and can those participants be students (senior design), international partners (NNL), or fuel suppliers, for example?
6. Are there plans for a critical experiment, and where/what timeline is being considered?
7. In the event that a critical benchmark experiment is performed, are there considerations for maintaining fuel for future utility such as in future experiments or training, and will funding be guaranteed to allow for proper evaluation, such as ICSBEP evaluation development and review?
8. Applicability of 10 CFR 70.24 to HALEU reactors and the feasibility of 10 CFR 50.68(b) to justify deferring criticality monitoring.
9. Are there expected to be special regulations with respect to commercial-scale HALEU facilities and transport?
10. Given international advertisement of the US HALEU program, does the NRC have opportunities to collaborate with international bodies (e.g., NNL, NEA) to provide their regulatory perspective on HALEU safety margins?

Some of the topics summarized in these responses were addressed in the presentations given or questions asked during the workshop, and others will be used to shape future discussions for the project.

3. WORKSHOP OVERVIEW AND PARTICIPATION

A total of 274 people were either registered or expected attendees for the workshop, and a total of 229 attended. Of the total attendees, 212 people attended solely via Microsoft Teams, and 17 attended in person. Registrants could specify affiliation, and the distribution of affiliation type for all expected attendees (registrants and coordinators) is summarized in Figure 3-1. The affiliation breakdown shows a large meeting interest from those in industry, representing 42% of all registrants. Registration from national laboratory affiliations was also high, representing 20% of registrants. Expected attendance from DOE and NRC combined represented 21% of the affiliation distribution. The full list of registrants and affiliation is provided in Table A-1 of APPENDIX A.

Although attendee affiliation information was not explicitly collected, 86% of virtual attendees could be associated with either a matching registrant or affiliation through their Microsoft Teams account. Thus, 30 virtual attendees, nine of which called in via phone, could not be associated with any affiliation. The distribution of all attendees, in-person and virtual, is plotted in Figure 3-2. With respect to attendees, industry was still the majority affiliation, comprising 32% of attendance.

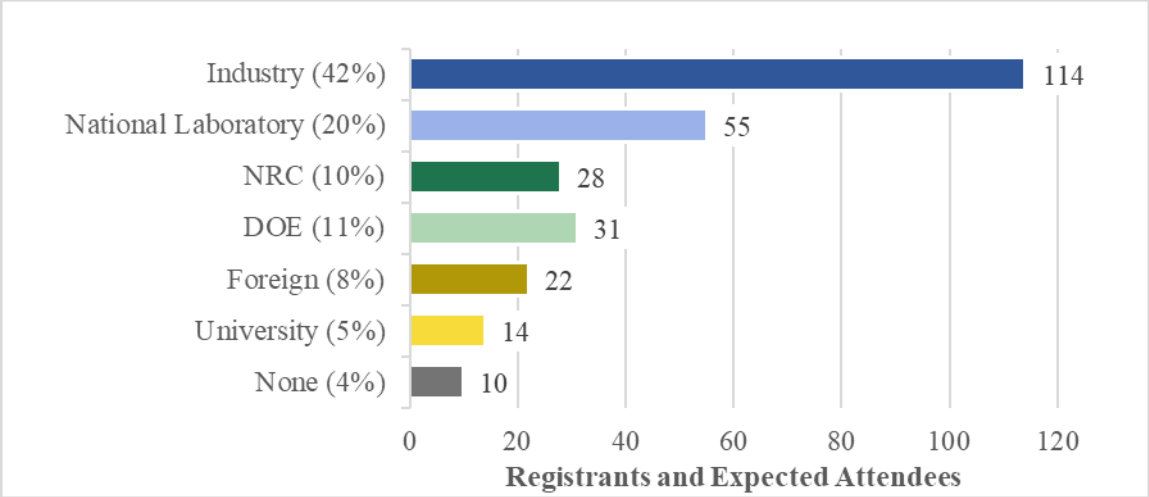


Figure 3-1. Summary of expected attendee affiliation

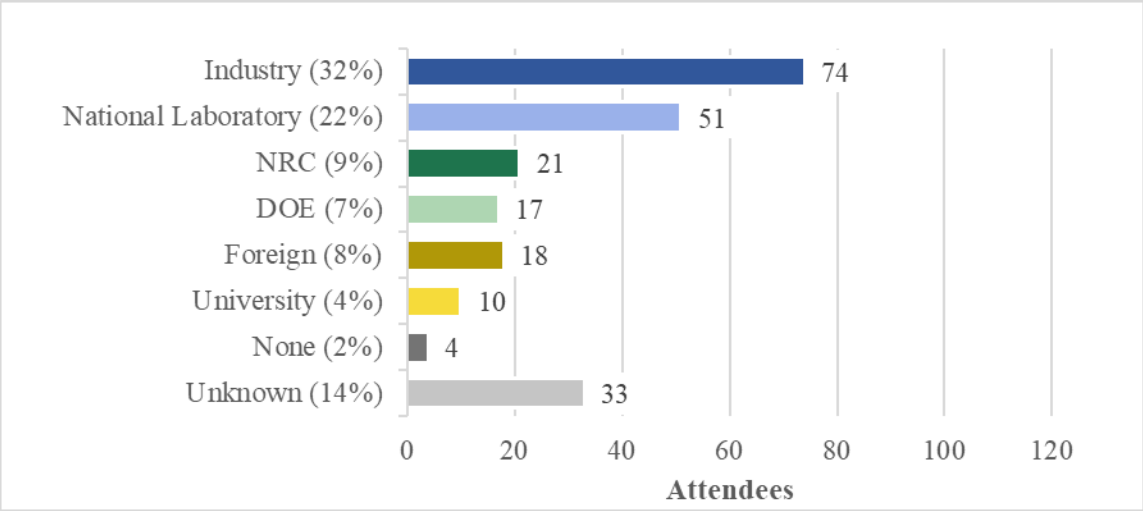


Figure 3-2. Summary of attendee affiliation

Regarding duration of virtual attendance, Figure 3-3 shows the call duration for those attendees who joined via MS Teams, discretized into half-hour increments. The majority, 55%, of virtual attendees remained on call for the full-length, 3+ hour time range. The average time spent in the meeting for virtual attendees was 2.5 hours.

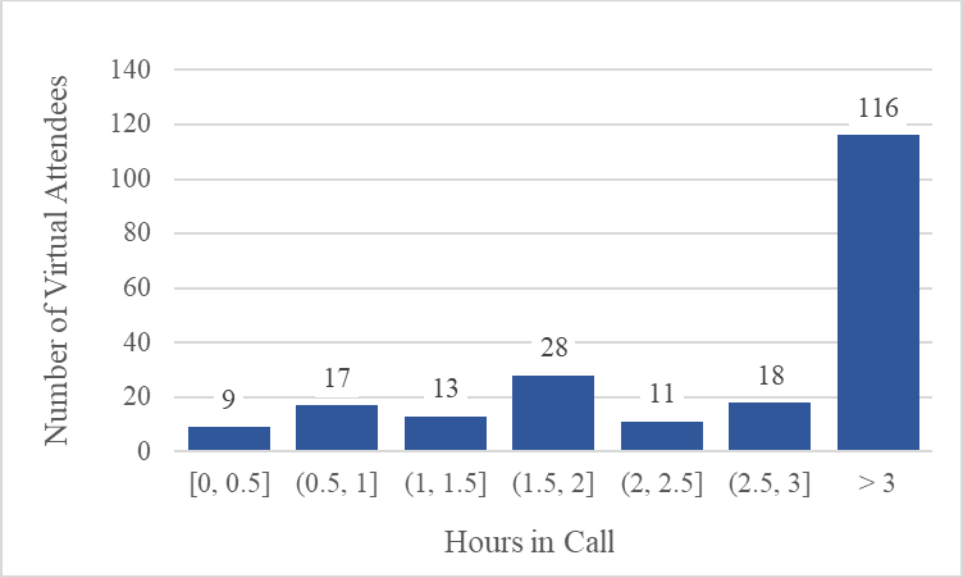


Figure 3-3. Distribution of time spent in the workshop meeting.

3.1 RELEVANT WORKSHOP INQUIRIES, RESPONSES, AND ADDITIONAL REMARKS

During the workshop, participants were encouraged to submit questions in the chat as well as during dedicated discussion times. This section details the in-scope questions and remarks received during the workshop by the attendees. Questions and live responses have been edited for clarity and technical content, and additional remarks are provided in some cases either to add context or respond to unaddressed questions. The slide deck is available via ADAMS under accession number ML24066A083 [2].

Question/Remark:

Will the slide deck be available afterwards?

Live Response:

Yes, the slides with an ADAMS accession number will be provided following the workshop.

Additional Remark:

The slides are accessible in .pdf format on ADAMS under accession number ML24066A083 [2].

Question/Remark:

There is Fast Flux Test Facility fuel at the Hanford Site. Will this be used?

Live Response:

None.

Additional Remark:

This is yet to be determined.

Question/Remark:

Are there any upcoming experiments covering 19.75 wt% ^{235}U-enriched, beryllium-moderated assemblies?

Live Response:

There is no existing 19.75 wt% fuel, so not at this point.

Additional Remark:

To the best of our knowledge, there is no existing 19.75% enriched uranium material in the inventory at either the National Criticality Experiments Research Center (NCERC) or the Sandia Pulsed Reactor Facility – Critical Experiments (SPR/CX) to support an experiment of this type today.

Question/Remark:

Available LWR experiments with higher enrichment than 5 wt% lack power distribution measurements. Experiments covering LWR fuel types with power distribution measurements are needed for HALEU deployment in legacy LWR reactors.

Live Response:

Unfortunately, in-reactor utilization is outside the purview of this project.

Question/Remark:

NCERC has 20% HALEU TRISO—CNPS [Compact Nuclear Power Source] fuel that could be of interest for benchmarking.

Live Response:

None.

Additional Remark:

This will be mentioned in our facility survey and incorporated in future considerations.

Question/Remark:

Why is 10CFR72 (storage) not addressed?

Live Response:

The Energy Act of 2020 [4] does not call out 10 CFR 72. Additionally, there are areas of emphasis that apply only to LWR systems in Part 72.

Question/Remark:

Can you describe future planned HALEU benchmarks involving salts (e.g., LiCl-Li2O, or similar)?

Live Response:

There are no current plans known to the participants.

Question/Remark:

Do you plan to work on UF_6 related benchmarks?

Live Response:

Performing benchmarks related to UF_6 would be of interest.

Question/Remark:

What is the timeline on the different phases of this project?

Live Response:

None

Additional Remark:

One of the current constraints of the project is to have funding commitments in place by the end of FY26. We are tentatively planning for three calls for proposals to address experimental needs. Call #1 is slated to occur in early April with approximately 2 months to submit proposals and 1 month to review and award. Call #2 will likely occur near the end of FY24 / beginning of FY25. Call #3 will occur in early FY25. The proposals awarded from these calls will put into motion a number of experiments and benchmarking activities that will be managed by the project team (tentatively) into FY28.

Question/Remark:

Is the project making requests for industry applications? Can industry submit prospective fuel applications for HALEU and receive this type of personalized report from the DOE under the scope of this project to assist individual parties with their validation?

Live Response:

None

Additional Remark:

Those interested in reaching out to collaborate, have discussions, improve resource availability for the project, or simply be made aware of future proposal calls are encouraged to connect with us at DNCSH@ornl.gov.

Question/Remark:

How useful are critical experiments with 'effective enrichments' in the 20% range? (E.g., mixture of HEU and DU fuel that averages to ~20% enriched.)

Live Response:

None

Additional Remark:

This could be investigated under a proposal submitted to the Experiment and Analysis Work-Packages.

Question/Remark:

Besides Terrapower/MCRE, are there other molten salt reactor designs that will be using uranium salts (not just salt as a coolant)?

Live Response:

MSRs are an area where there's uncertainty in how fuel would be transported. If there's any information industry can give, that would be appreciated. What kind of materials and salts, the fuel form—all could be a transportation issue. The NCSP is working on this with 2 experiments: a chlorine HEU experiment and a Li-6 absorption experiment. A recent experiment was evaluated with chlorine, all at thermal energies. The limiting condition is usually thermal upsets with water intrusion.

Question/Remark:

Is there a guide or standard on S/U similarity critical experiment selection?

Live Response:

There is a draft S/U guidance NUREG/CR scheduled to be published this calendar year.

Question/Remark:

For the hypothetical pebble tanker analysis, do you know why there was such a difference in applicable experiments with $c_k > 0.9$ for PBMR [pebble bed modular reactor] vs. Kairos pebble type, given their similarity on paper?

Live Response:

There is a plan to detail this, though the explanation will probably be unsatisfying with a general conclusion the likes of "The spectrum is different." The goal was to look at what industry was planning to identify possible gaps in an informed manner. Industry's planned approach is unknown, so the aim is to answer, "What experiment could be done to better answer that question?"

Question/Remark:

How close are relevant TSL [Thermal Scattering Law] covariance and sensitivity analysis capabilities? Is there any expectation that they would change c_k values?

Live Response:

TSL covariances or sensitivities do not exist currently. This project will be funding an initial scoping of whether accounting for TSLs matter for c_k. Calculated sensitivities are for 1-D cross sections only, using the free gas uncertainty with the 1-D sensitivity. How our view changes on this approach is an open question that will change as information becomes available.

Additional Remark:

More information will be available in an upcoming publication.

Question/Remark:

Can you comment on the quality of the covariance data for ENDF/B-VII.1 vs ENDF/B-VIII.0?

Live Response:

This was discussed internally this week, and calculations were rerun with ENDF/B-VIII.0. With ENDF/B-VIII.0, the c_k increased, with the primary expected reason being the dramatic increase in H-1. H-1 sensitivities become more important as the uncertainty increases, so its contribution becomes more important. As c_k is a normalized value, this increase also reduces the importance of other contributors. ENDF/B-VIII.0 indicated more applicable experiments for the TRISO systems, which falls under the understanding of the changes made to the covariance data.

Question/Remark:

In addition to experiments, are you considering past experience and data from operating reactors using various fuel types?

Live Response:

There are several reactor benchmarks derived from operational reactors. In general, the type of experiments and measurements found in the *ICSBEP Handbook* have lower uncertainty than such reactor experiments and are more useful for the criticality analysis. The analysis is informed by real world conditions the fuel may experience during transportation or processing. The discussion here is about developing experiments that are appropriate to make sure there is confidence in the models generated.

Question/Remark:

Most advanced fuels do not use water as moderator. For many fuel forms, hybrid heterogeneous moderation is a great concern for criticality safety. Such conditions can look like solution systems, but discussion of applicability can be an issue.

Live Response:

The next presentations will detail benchmark applicability and models built for flooded packages. The ingress of water is a 10 CFR 71.55 requirement.

Question/Remark:

Methods have come up in IRPhE [*International Handbook of Evaluated Reactor Physics Benchmark Experiments*] for adjusting nuclear data; are there efforts towards this in criticality safety?

Live Response:

From a methods development perspective, SCALE has a GLLS tool, TSURFER, that can do those analyses, and it is up to the applicant to prove what is applicable and helpful. DOE regulation is tied to ANS standard 8.24, which says those comparisons shall be done to critical or near-critical experiments. Such methods have not been evaluated for use in transportation analyses. ANS 8.24 is starting the process of looking at other methods to use beyond LCEs [Laboratory Critical Experiments], such as sensitivity analysis, and are open to looking at what's appropriate. Standards lag technology but are open to entertaining suggestions from people that have good and useful ideas.

Question/Remark:

There has been no progress on rulemaking for production. What is the status of rulemaking in all activity proposing to generate fuel up to 20% HALEU? HALEU production is ongoing at Centrus, with a run of 20 kg this past fall. They have no way to ship it and nobody to ship it to. If there's no market, why is there demand?

Live Response:

The NRC underwent a process to look at rules for HALEU. Rulemaking changes are happening, though the main effort is looking at 10 CFR 50 for storage and spent fuel pools that limits fuel to 5 wt%. The NRC is looking to change that. By and large, many other rules didn't need to be changed for HALEU enrichments. Packages with enrichments of all ranges have been certified for decades. There are packages that can ship HALEU powder. For Part 70/71 (fuel cycle and transportation), there is no major rulemaking underway. For HALEU supply and demand: there is a significant lead time for items discussed. Data updates have been reviewed for use by applicants and the NRC, taking up to 5–10 years. There was the example earlier of benchmarks in 2012 that were useful for recent approvals. It took years to plan. The initial planning for the 7uPCX experiments started in the early 2000s, taking 10 years for the experiment to happen, and another 10 years for it to be useful in licensing applications. There are other uses of this data, such as our understanding of nuclear physics and data, and other applications using the same data. The

purpose of funding is to support the activity. The prioritization is difficult while trying to have the likely best effect on the future, when needing commercial-scale HALEU production.

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4. POST-WORKSHOP REFLECTION

Following the workshop, a survey was sent to registered participants requesting feedback and information to improve DNCSH discussion. The questions included in this survey are listed below, and responses are listed in Table A-3 of APPENDIX A. The survey was sent out on Friday March 1, and it closed Wednesday March 6 at 6 PM.

1) The main objective of the workshop was to bring participants up to speed on the current DOE/NRC assessment of gaps in validation and nuclear data for HALEU-based fuel cycles. To what extent did the workshop meet its objective?

1 Star = Did Not Meet Objective
2 Stars = Needed Improvement
3 Stars = Expectations Met
4 Stars =Expectations Exceeded
5 Stars = Outstanding

2) What topics should we focus on in the near future to facilitate HALEU fuel utilization (fuel design, cask design, regulations, etc.)? Note that topics can be used in the funding opportunities for benchmark proposals.

Forty-two (42) responses were registered, a 19% response rate for attendees. Figure 4-1 presents the distribution of attendee feedback, with the average being 3.5 stars—between *Expectations Met* and *Expectations Exceeded*. Three attendees considered the workshop *Outstanding*; none considered that it *Did Not Meet Objective*. Table A-3 of APPENDIX A lists the ratings with the associated categorized open responses to Question 2.

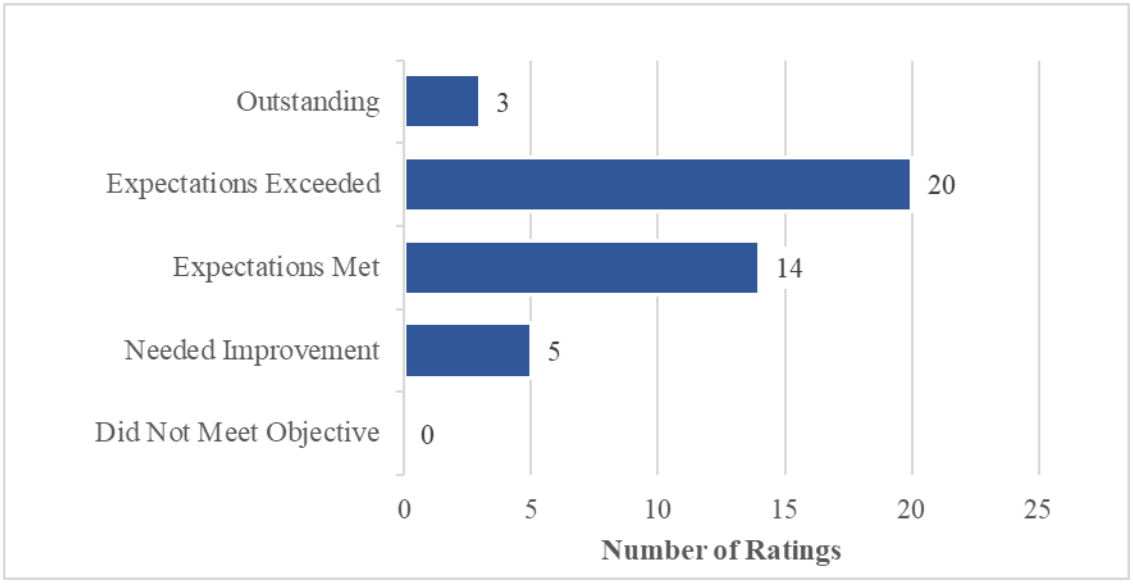


Figure 4-1. Distribution of feedback received following the workshop

Of the 42 registrant responses, 39 provided a response to Question 2. The common themes between these questions were categorized as follows:

Applications and Designs
: Responses related to better understanding the breadth of potential applications and designs for fuel types and suitable transportation packages

Regulations
: Responses related to wanting to better understand the current status and efforts regarding relevant regulations for the HALEU fuel cycle

NCS Methodology
: Responses related to exploring criticality safety analysis methods and validation given the existing gaps and unique features of advanced reactor HALEU fuel

Industry Inclusion
: Responses suggesting increasing outreach to and involvement of industry partners in these efforts to better understand their needs and applications

Experimental Needs
: Responses related to interest in experimental benchmark execution, nuclear data gaps, and their relevance to industry needs

Back-end
: Responses related to readiness for spent HALEU fuel transportation and storage

Figure 4-2 shows the breakdown of categories common among responses, to which between 1 and 3 categories were attributed. Requests for information about how HALEU is expected to be commercially implemented were the dominating theme. Additionally, responses emphasized a need to better connect industry, regulators, researchers, and experimentalists to better optimize the path forward. This follows the findings of the survey taken before the workshop, and intrinsically, it is an aim of the workshop to initiate discussion between relevant bodies to understand the needs of industry so that they can be addressed. This also demonstrates that the workshop itself did not act as a suitable avenue for addressing these questions, nor did it provide opportunity for industry to provide such information, as specifically noted by those requesting additional industry inclusion. Beyond the comments dedicated primarily to increased industry involvement, many desired additional time dedicated to workshop topic discussions.

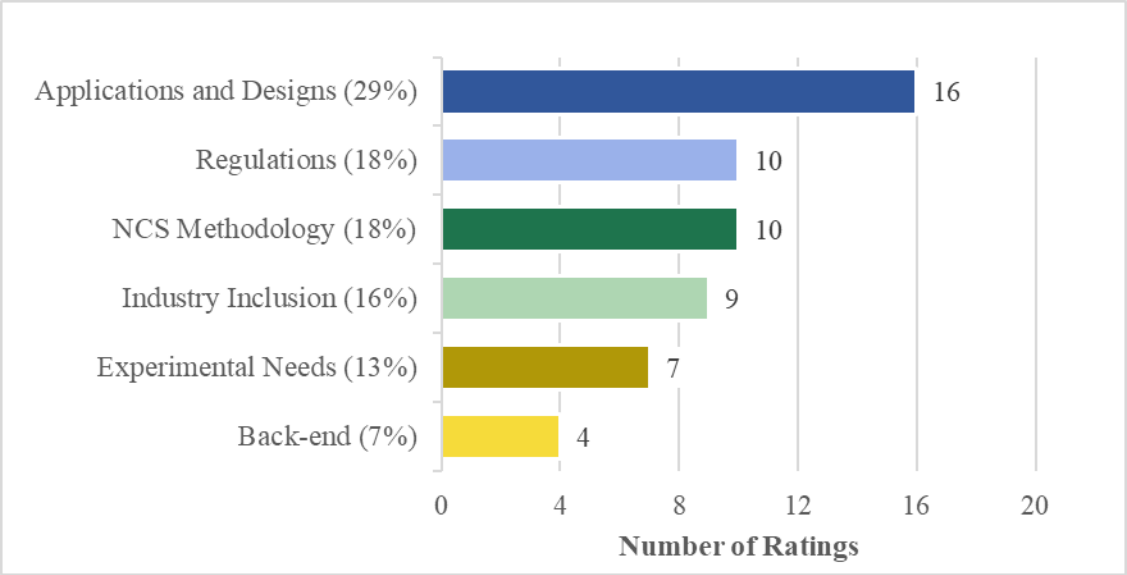


Figure 4-2. Categorization of post-workshop survey results

5. ACKNOWLEDGEMENTS

This work was funded by the U.S. Department of Energy, Office of Nuclear Energy and would not be possible without the support and collaboration with DOE-NE, the U.S. HALEU Consortium, and the U.S. Nuclear Regulatory Commission.

6. REFERENCES

[1] H.R.5376 - 117th Congress (2021–2022): Inflation Reduction Act of 2022. (2022, August 16). https://www.congress.gov/bill/117th-congress/house-bill/5376

[2] U.S. Nuclear Regulatory Commission, "DNCSH Public Workshop No. 1 – Complete Slide Deck," (2024, February 29). https://adamswebsearch2.nrc.gov/webSearch2/main.jsp?AccessionNumber=ML24066A083

[3] Fassino, L., Dupont, M., Al-Qasir, I., et al., "Current State of Benchmark Applicability for Commercial-Scale HALEU Fuel Transport," (2024). ORNL/TM-2024/3248. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

[4] Energy Act of 2020. (2020, December 21). https://science.house.gov/2020/12/energy-act-of-2020

APPENDIX A. SURVEYS AND ATTENDEE INFORMATION

Table A-1. Self-reported workshop registrants and affiliations

Registrant	Affiliation	Registrant, cont.	Affiliation, cont.
Aaron Tamashiro	LLNL	Bruce Bevard	ORNL
Abraham Weitzberg	self-employed	Calvin Hopper	CS Engineering
Afaf Wasili	Jazan University	Carl Friesen	DOE-ID
Aladar Csontos	NEI	Carmen Mendez	SNL
Alex Lang	ORNL	Catherine Percher	LLNL
Alex Shaw	ORNL	Charle Rombough	CTR Technical Services
Alex Siwy	NRC	Charles Stuart	INL
Alexander Vasiliev	Paul Scherrer Institute	Charlie Murphy	Westinghouse
Alexis Sotomayor-Rivera	NRC	Charlotta Sanders	UNLV
Alfie O'Neill	NNL UK	Charlotte Davis	Nuclear Transport Solutions
Alicia Walls	BWXT	Chris Backus	ORANO
Alison Hahn	DOE-NE	Chris Campbell	Kairos
Amrit Patel	Oklo	Chris Peet	Framatome
Andres Morell-Pacheco	SNL	Chris Stanek	LANL
Andrew Bielen	NRC	Christo Leibenberg	LIS Technologies
Andrew Brown	Westinghouse Springfield	Christopher Clemes	Dominion Energy
Andrew Prichard	N/A	Christopher Hurt	Bechtel
Andrew Ward	Univ of Michigan	Christopher Lewis	Framatome
Angela Chambers	NCSP	Clint Medlock	Southern
Aurelie Bardelay	IRSN (France)	Clinton Gross	Paschal Solutions Inc.
Ayman Hawari	NC State	Courtney Thomas	Oklo
Benjamin Nelson	Framatome	Dale Lancaster	NuclearConsultants.com
Bill McCaughey	DOE-NE	Dallas Moser	Triso-X
BJ Marshall	ORNL	Dan Beacon	Nuclear Regulatory Commission
Bob Rova	DOE-NE	Dan Leistikow	Centrus Energy
Boyce Travis	NRC	Daniel Beacon	Nuclear Regulatory Commission/NRR
Brad Beatty	ConverDyn	Daniel Forsyth	Nuclear Regulatory Commission
Brad Rearden	X-Energy	Daniel Galicki	BWXT
Brenda Spriggs	Fluor BWXT	Daniel Siefman	UC Berkeley
Brian Ade	USNC	Dante Johnson	Nuclear Regulatory Commission
Brooke Conrad	Westerman Nuclear	Dave Brown	BNL
David Ames	SNL	Germina Ilas	ORNL
David Barrientos	GE	Greg Hula	DOE
David Cline	Westerman	Guoquiang Wang	PNNL
David Eghbali	Global Nuclear Fuel	Hagen Childers	Fluor BWXT

Registrant	Affiliation	Registrant, cont.	Affiliation, cont.
David Livingston	BWXT	Hatice Akkurt	EPRI
David Luxat	SNL	Holger Pfeifer	NAC Intl
David Trudell	Canadian Nuclear Laboratories	Hossein Esmaili	Nuclear Regulatory Commission
Deborah Hill	National Nuclear Laboratory	Ian Hill	OECD/NEA
Dennis Mennerdahl	E Mennerdahl Systems	Ishita Trivedi	INL
Derrick Faunce	BWXT	Iyad Al-Qasir	ORNL
Diana Li	DOE-NE 5	Jack Edlow	Edlow Intl
Dirk Cairns-Gallimore	DOE-NE 5	Jacob Glessman	LLNL
Donna Gilmore	SanOnofreSafety.org	James Breuninger	DOE-NE 5
Donovan O'Mara	BWXT NOG	James Cleaver	Bechtel
Doug Bowen	ORNL	James Degolyer	GE
Douglas Bender	Mission Support and Test Services	James Drabble	Nuclear Regulatory Commission
Dr. Ayodeji Alajo	Missouri S&T	James Fornof	Lightbridge Corporation
Dr. Joseph Graham	Missouri S&T	James Freels	Urenco USA
Drew Barto	Nuclear Regulatory Commission	James Kelley	BWXT
DV Rao	LANL	James Morman	ANL
Dylan Ward	NAC Intl	Janelle Eddins	DOE-NE 5
Ed Lahoda	Westinghouse	Janet Schlueter	Nuclear Energy Institute
Eliezer Goldfeiz	Nuclear Regulatory Commission	Jason Hou	NCSU
Elisa Calvo Tone	Framatome	Jason Huffer	Navarro
Elnaz Seylabi	Univ of Nevada-Reno	Jeff Cardoni	SNL
Eric Aboud	LLNL	James Kelley	BWXT
Erik Gonsiorowski	Orano	James Morman	ANL
Evan Dolley	GE	Janelle Eddins	DOE-NE 5
Everett Redmond	Oklo	Jeff Powers	BWXT
Francesca Mallett	PNNL	Jeff Reed	Framatome
Frank Goldner	DOE	Jennifer Gutierrez	Nuclear Regulatory Commission
Frank Pulciano	Nevada National Security Sites	Jeremy Munson	Nuclear Regulatory Commission
Fred Beranek	Fluor	Jeremy Smith	Nuclear Regulatory Commission
Georgeta Radulescu	ORNL	Jesse Carlson	Nuclear Regulatory Commission
Jesson Hutchinson	LANL	Kim Coggins	NNL UK
Jesus Diaz-Quiroz	Global Laser Enrichment	Krista Kaiser	Bechtel
Jetta Goda	LANL	Kurt Terrani	USNC
Jim Freels	Urenco USA	Larry Wetzel	N/A

Registrant	Affiliation	Registrant, cont.	Affiliation, cont.
Joby Rosenleaf	BWXT	Lauren Flint	National Nuclear Laboratory
Joel Kreitzberg	Framatome	Lawrence Gelder	DOE-NE
John Bess	JFoster & Assoc	Lee Stahl	MSTS/Spectratech
John Hannah	GE	Leslie Duncan	BWXT
John Joyce	USNA	Lisa Davies	Fluor
John Miller	SNL	Lisa Fassino	ORNL
John Pevey	X-Energy	Logan Crevelt	Nuclear Regulatory Commission
John Salasin	BWXT	Lon Paulson	GE
John Scaglione	SpectraTech	Lucas Kyriazidis	Nuclear Regulatory Commission
John Schwenker	MSTS	Lujain Alobaide	NNSS/MSTS
John Warmack	Warmack & Company	Luke Yaraskavitch	CNL
Jonathan Marcano Lozada	Nuclear Regulatory Commission/NRR	M. Clint Medlock	Southern
Jonathon Walker	BWXT	Madeline Feltus	DOE
Jordan McDonnell	ORNL	Mark Cheng	University of Alabama
Josh Bergman	BWX Technologies	Mark Dehart	INL
Josh Jarrell	INL	Mark Massie	Antares
Joshua Whitman	Nuclear Regulatory Commission	Mark Neeley	PNNL
Jules Monnet	Jimmy Energy	Martin Karr	Centrus Energy
Julian Atfield	CNL	Mathieu Dupont	ORNL
Julie-Fiona Martin	OECD/NEA	Matt Hahn	DOE-NE 5
Justin Clarity	PNNL	Max Morrow	Orano
Justin Monito	BWXT	Michael Rose	Nuclear Regulatory Commission
Ju-Yuan Yeh	Framatome	Michael Shaughnessy	Iron People
Kat Abbott	DOE-NE 5	Michelle Nuttall	Nuclear Transport Solutions
Katie Murphy	DOE-Idaho	Mike Call	Nuclear Regulatory Commission
Kaushik Banerjee	PNNL	Mike Harkin	Framatome
Keith Jankowski	DOE-NP	Mike Houts	NASA
Keith Means	Westinghouse	Mike Wenner	Westinghouse
Kermit Bunde	DOE	Mike Zerkle	NNL
Mohamed Ouisloumen	Westinghouse	Steve Rhyne	NuGen
Muhammet Ayanoglu	self-employed	Steve Van Volkinburg	Navarro
Mykola Boychenko	Westinghouse	Steven Muller	Nuclear Regulatory Commission
Myron Kaczmarsky	Holtec	Sylvia Saltzstein	SNL

Registrant	Affiliation	Registrant, cont.	Affiliation, cont.
Nader Satvat	Kairos	Tanya Sloma-DeLosier	Westinghouse
Nate Howard	DOE-OCED	Tatiana Ivanova	OECD/NEA
Nathan George	X-Energy	Temitope Taiwo	ANL
Nathanael Hudson	Nuclear Regulatory Commission	Theresa Cutler	LANL
Ned Larson	DOE-NE8	Thien Nguyen	ORNL
Neil Herman	BWXT AT	Thomas DeLorey	BWXT
Nicholas Thompson	LANL	Thomas Miller	ORNL
Nick Grenci	Oklo	Tim Tate	Framatome
Norma Garcia Santos	Nuclear Regulatory Commission	Tim Trumbull	NNL
Olimpio Torres	Urenco USA	Timothy Drzewiecki	Kairos
Oliver Buss	OECD/NEA	Tk Kim	ANL
Olivier Gandou	ORANO	Tom Boyce	Nuclear Regulatory Commission
Omar Garcia	Triad	Tom Drury	TerraPower
Otto Linsuain	PNNL	Tracey Henson	Paschal Solutions, Inc.
Patrick Everett	Oklo	Travis Wilson	Triso-X
Paul Sentieri	Battelle Energy Alliance	Travis Zipperer	PNNL
Pedro Ortego	Science Engineering Associates	Tyler Naughton	BWX Technologies
Peter Hastings	Kairos Power	Ugur Mertyurek	ORNL
Quentin Newell	Urenco USA	Veera Gude	Purdue
Richard Lagdon	Bechtel	Vefa Kucukboyaci	Westinghouse
Richard Montgomery	TRISO-X	Vladimir Khotylev	Canadian Nuclear Safety Commission
Rick Migliore	TerraPower	Walid Metwally	ORNL
Rike Bostelmann	ORNL	William Doane	Framatome
Robert Iotti	ARC Clean Tech	William Gerding	BWX Technologies
Ruqayyah Shouk	Jazan University	William Newmyer	21 Consulting Group
Savannah Fitzwater	DOE-NE 5	William Walters	Westinghouse
Scott Palmtag	NCSU	Wyatt Padgett	Urenco USA
Scott Sanborn	SNL	Yang Liu	Virginia Tech
Sean Cunningham	BEA	Yevgeniy Terekhin	TN Americas
Shenyang Hu	PNNL	Yong Yang	U of Florida
Yung Liu	ANL	Zenon Barnicoat	Canadian Nuclear Laboratories
Zee St Hilaire	Nuclear Regulatory Commission	Zeyun Wu	Virginia Commonwealth
Zenghu Han	ANL		

Table A-2. Submitted responses to initial survey

Assigned Category	Inquiry
Project Logistics	Is there any opportunity to include undergraduate senior projects.
Benchmark/Industry Needs	Nuclear Industry integral experiment/benchmark needs
Benchmark/Industry Needs	Relevance of reactor physics benchmarks for criticality safety and NRC needs.
Benchmark/Industry Needs	Potential needs related to HALEU fueled space nuclear power and propulsion systems
Benchmark/Industry Needs	"The workshop is intended to bring participants up to speed on the current DOE/NRC assessment of gaps in validation and nuclear data for HALEU-based fuel cycles and collect feedback which will be used to inform the first call for benchmark proposals". The front-end and the back-end are equally important for a fuel cycle. Would the workshop discuss any related validation and nuclear data needs for the back-end of HALEU-based fuel cycle, from the perspective of NRC's needs?
Benchmark/Industry Needs	Criticality benchmarks for HALEU containing lithium and chlorine.
Data/Methods/Analysis	Validation and NCS application
Benchmark/Industry Needs	Critical experiments
Transport/Process	Transport of fuel from enricher to fabricator and transport of fabricated fuel to power plant.
Benchmark/Industry Needs	NRC HALEU needs.
Data/Methods/Analysis	V&V of analytical models to support HALEU fuel forms
Data/Methods/Analysis	Any known or suspected nuclear data shortfalls.
Regulation	What does the NRC require to approve HALEU applications?
Transport/Process	Mostly interested in the package related topics but also interested in facility related discussions.
Data/Methods/Analysis	Uncertainty and sensitivity analysis
Benchmark/Industry Needs	Benchmarks
Benchmark/Industry Needs	Critical benchmark needs involving HALEU at 20% enrichment (oxide, u-metal, other)
Regulation	Licensing Environment and Expectations, Transportation of HALEU Material, Change in Security Requirements, Expected Future Regulatory Guidance, and Any potential Changes to Regulations.
Project Logistics	Any challenges related to data availability of HALEU fuel (criticality, materials, etc.)
Project Logistics	Understand what the plans are for new HALEU-related critical experiments
Data/Methods/Analysis	Uncertainty quantification, benchmark design, nuclear data
Transport/Process	Criticality concern in Sol-Gel process (similar to NCSET Module 10 and 11)
Data/Methods/Analysis	Methods for assimilation of integral experimental data and the effect on nuclear data uncertainty

Assigned Category	Inquiry
Regulation	Applicability of 10 CFR 70.24 to reactors that use HALEU and establishing a pathway for using 10 CFR 50.68(b) to justify deferring criticality monitoring. Discussion of exemptions or exceptions for HALEU applications from requirements in the CFRs that specify LEU (<5%) enrichment (e.g., 10 CFR 50.68(b)). Discussion of criticality safety for NRC licensing of research reactors that use HALEU using NUREG-1537, including the interaction of the prescribed USL of 0.90 with the proposed benchmarking work for HALEU fuel.
Benchmark/Industry Needs	Interested in the topic generally as am currently developing critical parameters and considering validation approach for HALEU fuels - hence this aligns very well with my current area of focus. One area I am very interested in is how good a job we feel existing experiments do at representing HALEU applications.
Project Logistics	Critical experiment parameters and planning, shipping concerns
Data/Methods/Analysis	Modeling effort in material property degradation and remote detection
Benchmark/Industry Needs	Fuel types to support the advanced reactor deployment.
Benchmark/Industry Needs	High priority material needs for benchmark experiments
Project Logistics	Back up plans if Sandia doesn't work out for critical assembly.
Transport/Process	Any cross-over relationship to MOX? Anyone using the Pellet H/U Optimization Eq. ?
Regulation	Needs for determining criticality safety for HALEU enrichment processes. Licensing approaches for Integrated Safety Analysis to support Part 71 License Applications for a HALEU facility Security Considerations for HALEU facility.
Regulation	1. Criticality needs for determining criticality safety for HALEU enrichment processes 2. Licensing approaches for Integrated Safety Analysis for a Part 71 licensing 3. Security considerations for HALEU
Benchmark/Industry Needs	I would like to hear about NRC/DOE anticipated acceptable methods and preliminary, or existing, critical experiment benchmark designs necessary for validating safety analyses of TRISO HALEU-based fuel production.
Transport/Process	Development of the 30B Cylinders and Overpacks for HALEU UF6.
Transport/Process	Mostly interested in transportation
Benchmark/Industry Needs	Progress on new HALEU benchmarks and benchmarks supporting particle fuel modeling techniques.
Transport/Process	HALEU front end transport and backend transportation and storage/reprocessing/final disposal.

Assigned Category	Inquiry
Benchmark/Industry Needs	We are a manufacturer of UF6 transportation tanks based in Bremen, Ohio for LEU. Our team also manufacturers 5B, 8A, 12B, 30B, 48Y and 48X vessels currently. Is there a consensus on the preferred vessel size and overpack to transport HALEU? The 5B is suitable today but we are not sure the market is comfortable with the capacity of the vessel. We are interested in participating in a new or capacity expansion of an existing design to aid the market. We believe the vessels should be ASME approved to allow for competition and successful commercialization of HALEU.
Transport/Process	Recycling of DOE HALEU stockpile for fueling metal fueled fast reactor in mid 30s
Transport/Process	I'm interested to hear about the handling of HALEU during and after the enrichment process, and the storage of it at the enrichment facility. Associated with that is Criticality management, and the type of storage containers.
Benchmark/Industry Needs	Benchmark experiments
Regulation	Current NRC approach/requirements to evaluating safety evaluations given the lack of data on HALEU-based fuels
Transport/Process	Transportation and process criticality issues.
Benchmark/Industry Needs	We are a manufacturer of UF6 transportation tanks based in Bremen, Ohio for LEU. Our team also manufacturers 5B, 8A, 12B, 30B, 48Y and 48X vessels currently. Is there a consensus on the preferred vessel size and overpack to transport HALEU? The 5B is suitable today but we are not sure the market is comfortable with the capacity of the vessel. We are interested in participating in a new or capacity expansion of an existing design to aid the market. We believe the vessels should be ASME approved to allow for competition and successful commercialization of HALEU.
Regulation	Any special expectations/regulations with respect to commercial-scale facilities having HALEU material, and the method for which the HALEU will be received/transported.
Benchmark/Industry Needs	Benchmarks and plans for benchmarks for gas cooled reactors.
Data/Methods/Analysis	Methods and tools used for selection of criticality benchmarks that are relevant for the specific application cases.
Regulation	HALEU back-end: - are there issues in final disposal of relatively high enriched spent fuel? - are the plans to re-process spent HALEU fuel to be used for classical LEU based reactors?
Project Logistics	Funding opportunities for R&D
Project Logistics	Role and opportunities for the international community in supporting this US initiative.
Benchmark/Industry Needs	Pertinent industry needs with near-term actionable solutions and pathways for collaborative effort.
Data/Methods/Analysis	Uncertainties and validation

Assigned Category	Inquiry
Data/Methods/Analysis	Validation, NCS analysis approaches
Benchmark/Industry Needs	Full scope and segmentation of needs
Benchmark/Industry Needs	Industry plans for commercial-scale transportation to inform analysis work we're doing at the labs to help them. We need to know how to more effectively help them.
Benchmark/Industry Needs	HALEU Discharge Isotopics
Benchmark/Industry Needs	HALEU critical benchmark needs
Project Logistics	Availability of critical testing facilities for developing industry fuel codes
Data/Methods/Analysis	Validation
Benchmark/Industry Needs	Critical experiments using higher enriched fuel > 5wt% U235
Regulation	Metal hydride risks. Criticality and hydride risks from canister cracking. NRC states there can be a criticality if water enters canister through cracks. There is insufficient boron in canisters to prevent criticality. There is lots of hydrogen in Zircaloy-4 high burn fuel rods according to Brady Hanson. Current criticality and hydride risks need to be resolved before creating even worse problems with even higher burnups.
Benchmark/Industry Needs	Salt based fuels
Project Logistics	Timeline of the project and who the potential suppliers may for benchmark fuel if the project does progress to that point. Also, where the benchmarks might take place (like in Oak Ridge at a new facility or at the existing critical experiments facility) and if there would be any plans to keep the fuel for future experiments and/or to start educational programs outside of the existing DOE critical experiment programs.
Project Logistics	There is nothing new here, just a reminder. How the quality of the benchmarks (simplified models of experiments with propagated uncertainties in the results, intended for validation and nuclear data evaluation) can be improved by making incremental changes to a basic reference design (not changing anything in that design between measurements, if not absolutely necessary). Each parameter of interest can then be evaluated with minor uncertainty. A benchmark, being a simplified model and estimated result(s), is not only an experiment but a thorough evaluation of experiment(s) and preparation of a benchmark (or more) for calculation purposes. It is essential that funding for all this is assured from the start. Doing some of this evaluation before the final designing of the experiment should improve the quality of the results.
Data/Methods/Analysis	Crit. testing facilities. Large scale package validation testing.

Assigned Category	Inquiry
Regulation	HALEU fuel applications are currently receiving government support in the UK, and work is ongoing in (UK) National Nuclear Laboratory to determine an appropriate safety margin / EPD for such applications, with a focus on the real-world impact of overly pessimistic safety margins on industrial scale processing. It would therefore be very interesting to hear a US regulatory perspective on this, and also identify whether there are any potential opportunities to collaborate if there are places where UK criticality safety specialists could add value or aid a research program. Acknowledging how advanced and supported the US program is in comparison to work in the UK, it is very much appreciated that this being held as an open forum and advertised internationally via the OCED/NEA WPNCS.
Benchmark/Industry Needs	Benchmark needs in support of direct oxide electroreduction.
Transport/Process	HALEU Transportation
Transport/Process	Criticality aspects of processing
Transport/Process	Transportation, how HALEU facility constraints compare to LEU and HEU, anything specific about HALEU that is different than LEU and HEU and counterintuitive, current status in casks for HALEU (I think these were to be provided DOE/US Gov't for some ARDP or other projects?)

Table A-3. Submitted responses to post-workshop feedback survey

Rating	Open Response	Assigned Categories
4	More detailed view on the validation required and challenges of validating HALEU fuel.	NCS Methodology
4	Single parameter experimental data for HALEU, Similar to ARH-600, would be universally beneficial to all licensees. It would also be beneficial to discuss the abnormal conditions and hypothetical conditions for operating fuel fabrication, enrichment, or transport.	Experimental Needs NCS Methodology
2	Support for vendors to get criticals testing done to validate their neutronics codes. Facilities are very limited and this work is very expensive considering the amount of testing that is required.	Experimental Needs Industry Inclusion
3	Data availability, validation process and expected outcomes, regulations	NCS Methodology Regulations
3	Topics that focus on the longest lead items make sense. Off the cuff it seems that would be regulations, but anything that is "new" would also take time.	Regulations
4	Topics focused on needed application models would be greatly appreciated. The talks presented by ORNL were great, but it would be even better if industries could show their actual applications, as that is needed for any future designs to have maximum impact.	Industry Inclusion Applications and Designs
4	Used fuel composition, back-end considerations	Applications and Designs Back-End
4	The gaps, and/or filled gaps, for other fuel and chemical/alloy forms should be included from the standpoints of fuel form conversions through processing steams.	Applications and Designs
4	We should be working on defining experimental needs as well, to possibly twist arms to make such happen.	Experimental Needs Applications and Designs
2	Comprehensive evaluation of spent HALEU fuel management - storage and transport (10 CFR Part 72 and 71). This of course would include technical fuel and cladding degradation mechanisms (including hydrides), as well as proposed canister / cask storage systems, degradation mechanisms and corrective measures for short term, long term and indefinite time frames.	Regulations Back-End
4	Licensing of Overpacks for 5B and 30B UF6 cylinders containing HALEU.	Regulations
3	Presentations from the companies on their needs would have been more useful than some of the ORNL technical talks.	Industry Inclusion
4	Fuel design - HALEU from downblend.	Applications and Designs
4	Fuel design, process for fuel fabrication (and NCS assessment related to this process), validation of the validation methodology	Applications and Designs NCS Methodology
4	I would like to hear more about regulations. The discussions about technical improvements being made to support licensing were helpful, but many projects are moving forward before those improvements can be made available. I'd like to see more discussions about licensing HALEU with currently available data and how users can address existing data shortcomings.	Regulations NCS Methodology

Rating	Open Response	Assigned Categories
2	Fuel Design & Regulations	Applications and Designs Regulations
2	Really should have set aside an hour or so to let industry speak and tell you more of what they are looking into instead of assuming based on a literature review.	Industry Inclusion
4	New experimental data	Experimental Needs
3	I found the short descriptions of the various reactor projects to be good. Expanding on that topic would be interesting.	Industry Inclusion Applications and Designs
3	Though the topics and examples were interesting and shed light on the validation techniques, utilization and packaging designs are two completely different subject matters. Where gaps are found in the data, experiments at NCERC with CNPS Fuels or other available materials would be useful.	Experimental Needs
3	Fuel Design	Applications and Designs
5	Need to prioritize activities necessary to mobilize the industry to be able to handle and produce HALEU fuel by early 2032 or so. So testing, shipping containers, criticality analyses and other activities need to be prioritized based on an advanced reactor starting in 2032.	Industry Inclusion NCS Methodology Regulations
3	I think the people were quite interested in cask design, fuel inside the cask designs. BJ had a few questions on this	Applications and Designs
3	[Left blank]	N/A
3	UF6, along with oxide and metal transport packages	Applications and Designs
4	I'm looking forward to seeing more application models (e.g., HALEU salt) to better understand where there might be opportunities for benchmark proposals. I'm also curious to see how well credible scenarios for microreactor transport are covered. I had presumed vendors intended to transport constructed cores to site, what might the implications be to some of these HALEU systems provided they are in a flood scenario, imagining their k_eff is already significantly higher than other cases.	Applications and Designs NCS Methodology
5	I would be interested in the work being done in the regulatory framework.	Regulations
3	Fuel design, including high temperature usage.	Applications and Designs
3	TRISO fuel matrix appears to have received much attention thus far; more attention is needed to similarly portray u-metal / u-alloy benchmarks in support of alternate ARDP technologies (e.g,. SFR). UF6 enriched to 20% can be safely transported in the 'existing' Model 30B cylinder inside UX-30/ND-30 overpack (do the studies). Transport of u-metal lattices needs a package design (do conceptual / scoping studies). HALEU electroreduction of 20% enriched oxides to u-metal certainly needs more critical benchmarks involving various salts (e.g., UxOy+LiCl, UOx+LiCl, U+LiCl) under a variety of state point conditions.	Applications and Designs Experimental Needs

Rating	Open Response	Assigned Categories
4	I would like to hear more directly from the end user of such data, versus ORNL regulator, or those that perform critical experiments. What does the community really need, or are they not engaged enough to know they need it.	Industry Inclusion
4	Everything needed. Just don't make it so ORNL focused. The presentations felt really biased when there are so many other nuclear players in the US.	Industry Inclusion
3	Not sure. I had no explicit expectations about the workshop and am very new to the nuclear criticality safety field, I don't have enough perspective to give a comprehensive answer.	
4	Coated particle fuels - to understand impact of design and materials (interested in application to fabrication and transport). Intermediate energy spectrum behaviour (may be useful if fabrication / transport assessment dependent upon low moderation states). Interested in experiments using HALEU enrichments, although similar to BJ we seem to be seeing from early work that our systems are fairly well matched with existing low / high enrichment experiments.	Experimental Needs NCS Methodology
4	Understanding where the larger nuclear data uncertainties are which drive the value of c_k used in derivation of a safety margin, in order to tune experimental design.	NCS Methodology
3	[Left blank]	N/A
4	Ease of shipping higher enrichments of UF6. Up to 5-wt.% U-235 UF6 can be shipped now without considering optimal water moderation (10 CFR 71.55(g)), can this number be raised?	Regulations
5	Cask Design.	Applications and Designs
4	I think there is a big gap with how we are going to deal with the waste and therefore how to transport and store it long term	Back-end
4	Waste disposal	Back-end
4	Fuel design: focus on fuel fabrication need. * UF4 * Sol-Gel process (similar to NCSET module for PUREX)	Applications and Designs

Rating	Open Response	Assigned Categories
3	More industry involvement should be key. A closed meeting would be preferable because the out-of-scope comments were entertained a disproportionate amount, leaving little time for the conversation productive to collaboration. It needs to be a conversation with industry if we want to help industry. If it has to include the public, a live poll system that tracks whether the person is industry or public could help distinguish in-scope and out-of-scope material. A dedicated moderator would help control the conversation more too, because people should not be allowed to continually follow-up with ill-conceived and off topic questions/remarks. This could also help reach consensus on needs more efficiently. A second follow-up/feedback meeting could even be added to address this, and I think industry would be enthusiastic for that opportunity. In terms of what industry can provide, encouraging the development of more representative/proxy models for fuel would help get ahead on determining gaps in benchmark applicability and support integral experiment design.	Industry Inclusion
2	Better definition of near-term HALEU requirements (enrichment, alternative physical forms) and the interaction of those requirements with needed regulatory changes for use and transportation.	Regulations NCS Methodology