ORNL/TM-2025/4278

Participation in and Assessment of the Second DNCSH Public Workshop

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Walid Metwally
Veronica Karriem
William Wieselquist
Lindsey Aloisi
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Don Algama

October 2025

OAK RIDGE National Laboratory

ORNL IS MANAGED BY UT-BATTELLE LLC FOR THE US DEPARTMENT OF ENERGY

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Nuclear Energy and Fuel Cycle Division

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Prepared by
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ABBREVIATIONS

ADAMS	Agencywide Documents Access and Management System
BOL	beginning of life
BWR	boiling water reactor
DNCSH	DOE/NRC Criticality Safety for Commercial-Scale HALEU Fuel Cycle and Transportation
DOE	US Department of Energy
DOE-NE	US Department of Energy Office of Nuclear Energy
EAW	experiment and analysis work package
EBR-II	Experimental Breeder Reactor-II
EOL	end of life
FFTF	Fast Flux Test Facility
FHR	fluoride-salt-cooled high-temperature reactor
HALEU	high-assay low-enriched uranium
HTGR	high-temperature gas-cooled reactor
ICSBEP	International Criticality Safety Benchmark Evaluation Project
IFBA	integral fuel burnable absorber
LEU	low-enriched uranium
LWR	light-water reactor
MSR	molten salt reactor
NCS	nuclear criticality safety
NRC	US Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
S/U	sensitivity and uncertainty
TRG	Technical Review Group
TRIGA	Training, Research, Isotopes, General Atomics (reactor)
TRISO	tristructural-isotropic (fuel)
TSL	thermal scattering law

1. INTRODUCTION

The DOE/NRC Criticality Safety for Commercial-Scale HALEU Fuel Cycle and Transportation (DNCSH) project was established through the Inflation Reduction Act of 2022 (H.R. 5376) to support the US Nuclear Regulatory Commission (NRC) and industry in addressing critical experiment validation gaps that impede the licensing basis and regulatory approval of high-assay low-enriched uranium (HALEU) operations [1]. An initial public workshop was held in February 2024 to address HALEU transportation validation gaps [2]. The resulting call for proposals was released in April and resulted in funding for the execution and/or evaluation of 16 critical experiments [3].

A second public workshop was held in August 2025 to address facility and operational validation gaps, precluding a second call for proposals. A list of attendees is provided in APPENDIX A, Table A-1. A total of 319 participants joined the meeting, which was hosted online via Microsoft Teams as well as in person. The slides from the meeting were uploaded online to the NRC's Agencywide Documents Access and Management System (ADAMS) [4]. The meeting agenda is provided in Table 1-1 [5]. In preparation for the meeting, a study was performed to examine expected fissile forms for the fuel cycles of various fuel types at different stages of production and the apparent validation gaps [6]. The resulting report, titled "Benchmark Gap Assessment for the Manufacturing of High-Assay Low-Enriched Uranium Fuels," provided the foundation for the discussions that took place during the workshop [6]. The discussions and the validation gaps in the report were used to develop the second call for proposals [7].

The present report presents the feedback received before, during, and after the second workshop. All the data presented are based on voluntarily self-reported identification, opinions from workshop participants, and survey responses and are assumed to be as accurate as practically reasonable. The discussions during the workshop and the subsequent survey responses were intended to direct attention to industry-specific areas of interest and to collect feedback on the work performed to date by the DNCSH project.

Table 1-1. DNCSH August 2025 workshop agenda

Time	Topic	Speaker
1:00–1:15 p.m.	Welcome, Introduction, and Kickoff	NRC/DOE
1:15–1:25 p.m.	Pre-Workshop Survey Information	ORNL
1:25–1:50 p.m.	Current Benchmarks in Progress	LLNL
1:50–2:05 p.m.	Current Facility Activities	LANL
2:05–2:15 p.m.	Current Nuclear Data Activities	ORNL
2:15–2:25 p.m.	Recent NUREGs for Criticality Safety Validation	NRC
2:25–2:40 p.m.	Break	-
2:40–3:10 p.m.	Facility Focus Area for Call #2	BGS
3:10–3:20 p.m.	Application Models	ORNL
3:20–3:40 p.m.	Plan for Call #2 Timeline and Areas	ORNL NTD
3:40–4:00 p.m.	Q&A Discussion	ORNL NTD
4:00 p.m.	Adjourn	-

This report is structured chronologically. Section 2 presents the pre-workshop community survey. Section 3 presents information regarding the level of community participation and the inquiries made during the workshop; follow-up responses are provided for several areas of discussion for further transparency. Section 0 summarizes the feedback of the attendees following the workshop, including a rating for workshop efficacy and their topics of interest related to the validation and benchmark needs of the HALEU fuel cycle. Additionally, an appendix that contains detailed survey responses, attendee data, and affiliations is provided.

2. PRE-WORKSHOP SURVEY

Prior to workshop registration, a survey was sent to community members and other interested parties as potential participants. The survey was sent on May 28, 2025, and the details were as follows:

> ***Pre-workshop survey for the DNCSH Workshop #2***
> *The DOE/NRC Criticality Safety for Commercial-Scale HALEU Fuel Cycle and Transportation (DNCSH) project is dedicated to streamlining the nuclear criticality validation process for advanced nuclear reactor fuel technologies. Last year, a workshop was held with a focus on identifying nuclear data and validation gaps for HALEU fuel transportation.*
>
> *A planned Workshop 2 will address the validation gaps related to the manufacturing and fabrication of HALEU fuel at front-end facilities, building on insights from Workshop 1. A preliminary report prepared by Larry L. Wetzel and Cihangir Celik, "Benchmark Gap Assessment for the Manufacturing of High-Assay Low-Enriched Uranium Fuels" (February 2025, ORNL/TM-2025/3744), lays the groundwork for this initiative. To ensure a productive workshop and Q&A session, we invite input from community members and industry stakeholders on current or anticipated criticality safety validation needs. Your feedback will help guide our discussion on identifying benchmark needs for HALEU fuel facilities.*
>
> *Link to ORNL/TM-2025/3744 report: https://www.nrc.gov/docs/ML2506/ML25062A173.pdf*
>
> *1. Provide us your full name.*
> *2. Email address.*
> *3. Affiliation.*
> *4. Which of the following best describes your current role?*
> - *Criticality safety practitioner*
> - *Regulator*
> - *Operations*
> - *Research and Development*
> - *Other*
>
> *5. Which fuel cycle facilities are you most interested in?*
> - *Mining and Milling*
> - *Conversion*
> - *Enrichment*
> - *Fabrication*
> - *Transportation*
> - *Storage*
> - *Other*
>
> *6. Which HALEU fuel type are you most interested in?*
> - *UF_4-based fuel*
> - *UCl_3-based fuels*
> - *TRISO fuels*
> - *Oxide fuel*
> - *Metallic fuels*

U_3O_8/UF_6

Other

7. Rank the importance of the following areas to meet your facility need.

Additional benchmark experiments

Validation methods in nuclear criticality safety

Nuclear data

Application models with HALEU fuel

Supplemental analysis tools

8. Please elaborate on the areas of importance you identified in the previous question.

9. We value your insights! Please share your thoughts on the ORNL/TM-2025/3744 report by addressing the following:

- ***Focus Areas:** Are there any topics that you feel were either missing or not thoroughly addressed in the report and could help complete the discussion during the workshop?*
- ***Foreseeable Needs:** Do you have information/recommendations about applicable benchmarks, analysis, or models to help address the gaps identified in the report?*

Link to ORNL/TM-2025/3744 report: https://www.nrc.gov/docs/ML2506/ML25062A173.pdf

Your feedback is essential in advancing our discussion.

10. Are there other focus areas that should be covered in the workshop? Please elaborate.

11. Would you be interested in attending a training on validation methods in nuclear criticality safety related to commercial and licensing applications?

Yes

No

Maybe

12. Do you plan to attend the virtual workshop 2, tentatively planned for August 2025?

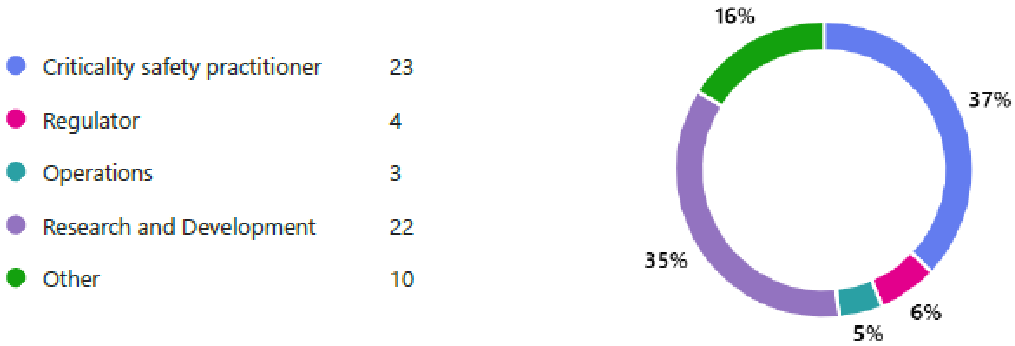
Yes

No

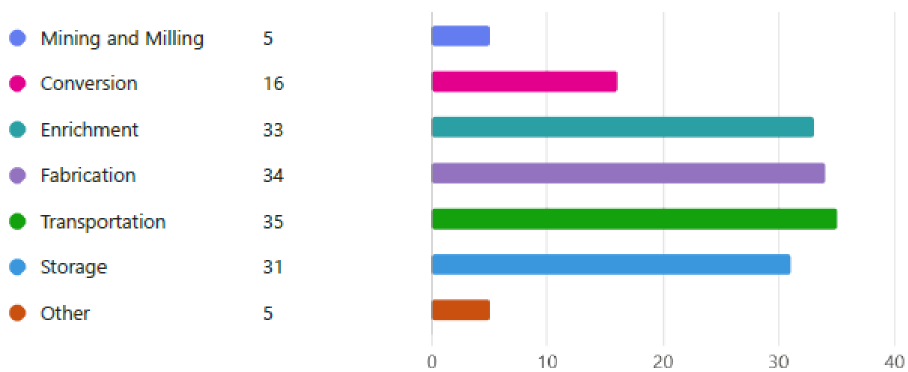
Maybe

Responses for multiple choice and ranking-based questions are provided below. A total of 51 participants recorded responses. Questions 4–7 allowed multiple responses. Open responses to Questions 8–10 are provided in APPENDIX A, Table A-2, Table A-3, and Table A-4.

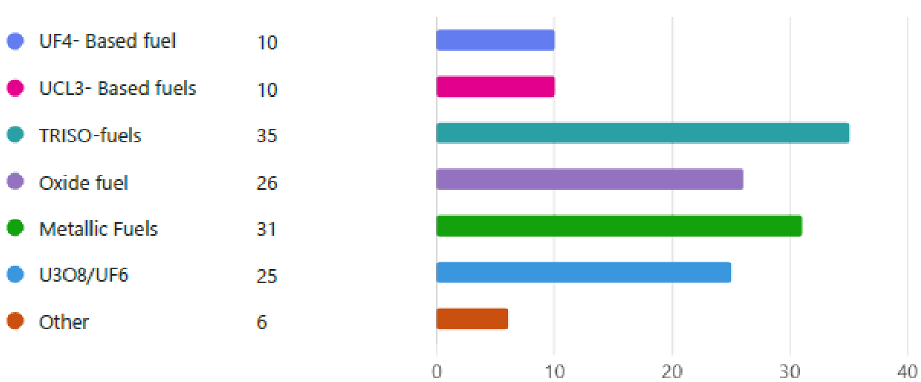
4. Which of the following best describes your current role?



5. Which fuel cycle facilities are you most interested in?

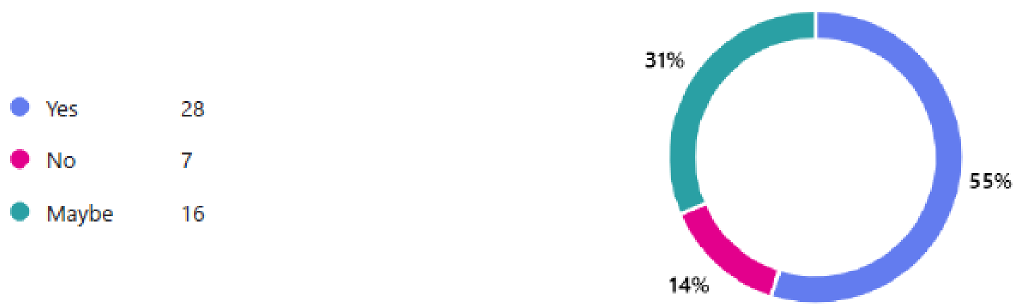


6. Which HALEU fuel type are you most interested in?



7. Rank the importance of the following areas to meet your facility needs

11. Would you be interested in attending a training on validation methods in nuclear criticality safety related to commercial and licensing applications?



12. Do you plan to attend the virtual workshop 2, tentatively planned for August 2025?

3. WORKSHOP OVERVIEW AND PARTICIPATION

The registration page for the workshop received 1,121 views online, and 449 people registered. Five registrants canceled their registrations. A total of 319 individuals attended the workshop. Of the attendees, 305 attended solely via Microsoft Teams, and 14 attended in person. The distribution of the affiliations of the attendees is summarized in Figure 3-1. The affiliation summary shows high participation from industry, representing 40% of all attendees. Participation of government and national laboratory affiliates was also high, representing 28% and 19% of attendees, respectively. Attendance from the US Department of Energy (DOE) and the NRC combined represented 19% of the affiliation distribution. The full list of attendees and affiliations is provided in Table A-1 of APPENDIX A.

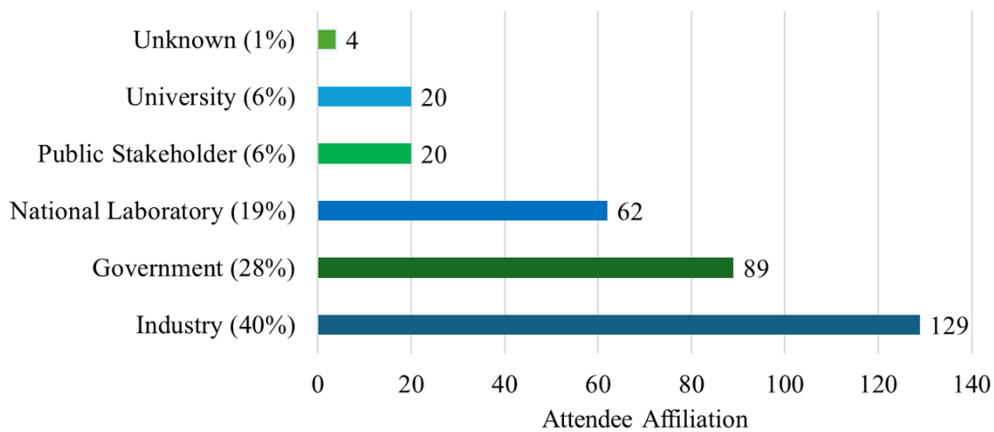


Figure 3-1. Summary of attendee affiliation.

Figure 3-2 shows the call duration for the attendees who joined via Microsoft Teams, discretized into quarter-hour increments. The average time spent in the meeting for virtual attendees was 1.25 hours; 147 attendees spent between 1.5 and 1.75 hours in the meeting.

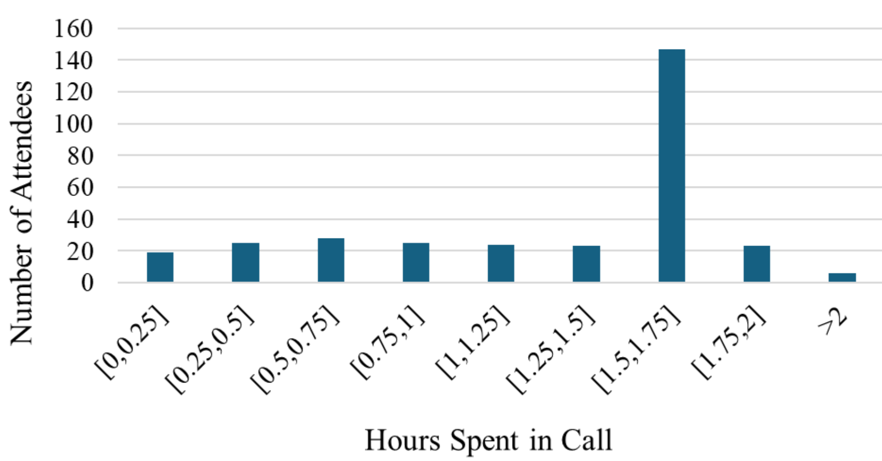


Figure 3-2. Distribution of time attendees spent in the workshop meeting.

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 periods. This section details the in-scope questions and remarks received from attendees during the workshop. 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 ML25252A200 [4].

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 ML25252A200 [4].

Question/Remark:

Has there been a rulemaking on HALEU, LEU+, reprocessing?

Has public notice been made and could you provide the ML# or URL for those [rulemaking] documents.

Live Response:

There are some rulemaking activities underway for increased enrichment. You can find publicly available information for a rulemaking for increased enrichment at the link below: https://www.regulations.gov/docket/NRC-2020-0034.

Question/Remark:

Projects have been going on for some time now. Are there public intermediate progress reporting stages for these projects to communicate their current status?

Live Response:

Work is ongoing to update the DNCSH website to provide awardee status. Backup workshop slides also provide additional information, generally with a current status. Before public release, interested parties may contact the PIs if the information is understood as preliminary. The first round of submissions to the International Criticality Safety Benchmark Evaluation Project (ICSBEP) Technical Review Group (TRG) will occur in April 2026 for some experiments and in 2027 for others.

Additional Remark:

Please continue to check the DNCSH website (https://www.ornl.gov/dncsh) for updates.

Question/Remark:

Will a participant list be provided for this meeting?

Live Response:

Information about attendees will be included in the meeting summary.

Additional Remark:

APPENDIX A provides the list of meeting participants.

4. POST-WORKSHOP REFLECTION

Following the workshop, a survey was sent to attendees to request feedback and information to improve DNCSH discussion. The questions included in this survey are listed below, and responses are listed in Table A-5 of APPENDIX A. The survey was distributed on Wednesday August 27, 2025, and remained open for 8 days.

> *1. Full name (Optional. You may choose to remain anonymous.)*
> *2. Email address.*
> *3. Affiliation.*
> *4. The objective of the second workshop was to summarize the ongoing activities from the first DNCSH call for experiment and analysis work packages (EAWs) and identify potential validation gaps to support the manufacturing and fabrication of HALEU fuel. To what extent was the second workshop effective in achieving this objective?*
>> *-Not at all effective*
>> *-Slightly effective*
>> *-Moderately effective*
>> *-Mostly effective*
>> *-Fully effective*
>
> *5. What topics should we focus on to support the validation and benchmark needs related to manufacturing, fabrication, and facility operations of HALEU fuel? Note that topics may be used in the funding opportunities for the second DNCSH proposal call for EAWs.*

Forty-one (41) responses were recorded, representing a 13% response rate for attendees. Figure 4-1 presents the distribution of attendee feedback. The average is 3.98 stars (*Mostly effective*). Eight attendees considered the workshop *Fully effective*; none considered it *Not at all effective*. Table A-5 of APPENDIX A lists the ratings with the associated categorized open responses to Question 4. Most responses were submitted by participants who rated the workshop as *Mostly effective* or *Fully effective*.

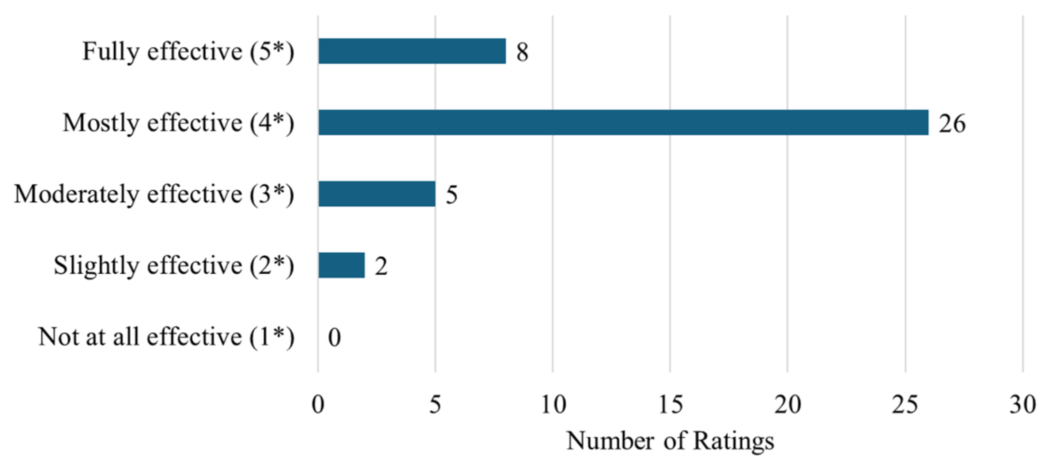


Figure 4-1. Distribution of feedback received following the workshop.

Of the 41 registrants who provided responses, 36 provided a response to Question 5; one response is considered fully out of scope. The common themes between these responses are categorized as follows:

Applications and Designs

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

Back End

Responses related to readiness for spent HALEU fuel transportation and storage

Experimental Needs

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

Nuclear Criticality Safety (NCS) Methodology

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

Regulations

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

Figure 4-2 shows the distribution of categories assigned to responses, as also presented in the third column of Table A-5. Responses related to Experimental Needs and Applications and Designs comprise two thirds of responses, though the length and complexity of responses vary substantially. To a lesser extent, there remains interest in the role of NCS Methodologies and Regulations. Considerations for the Back End were mostly ignored. These results are in contrast to the results of the pre-survey report, where "Validation methods in nuclear criticality safety" was the second highest concern behind "Additional experimental benchmarks," and "Application models with HALEU fuel" was the second lowest category of interest. Obvious differences are the survey populations as well as the more arbitrary categorization of post-workshop responses.

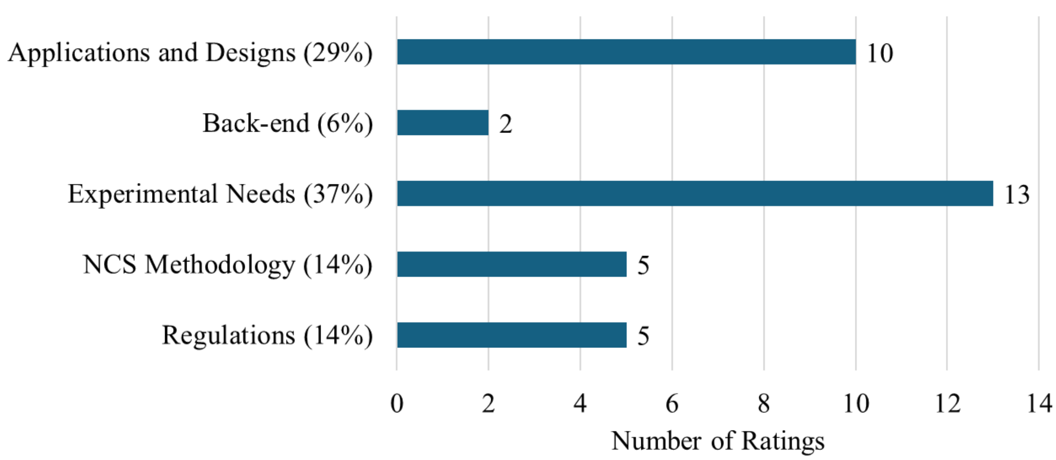


Figure 4-2. Categorized post-workshop survey results.

The post-workshop ratings and responses for the first DNCSH public workshop were compared with those of the second DNCSH public workshop. The average rating on a similar 1–5 scale was 3.50 for the first workshop, and this rating increased to 3.98 for the second workshop [8]. The categorization of post-workshop responses showed that requests for industry inclusion were no longer a primary theme of responses (16% in the first workshop) [8]. Optimistically, this represents potential industry satisfaction in inclusion in the first EAW proposal call. Back End, Regulations, and NCS Methodology responses were static between workshop surveys, as were responses for Applications and Designs. Therefore, it appears that rather than feeling a need to specifically request industry inclusion, participants felt that directly sharing experimental needs would be productive.

5. ACKNOWLEDGMENTS

This work was funded by the US Department of Energy Office of Nuclear Energy (DOE-NE) and would not have been possible without the support of and collaboration with DOE-NE, the US HALEU Consortium, and the NRC.

6. REFERENCES

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[2] U.S. Nuclear Regulatory Commission, "DNCSH Public Workshop No. 1 – Complete Slide Deck," (February 29, 2024). https://www.nrc.gov/docs/ML2406/ML24066A083.pdf.

[3] U.S. Department of Energy, "U.S. Department of Energy awards $17 million for first round of HALEU criticality benchmarking," (October 17, 2025). https://www.energy.gov/ne/articles/us-department-energy-awards-17-million-first-round-haleu-criticality-benchmarking.

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[7] Oak Ridge National Laboratory, "EAW-2 Proposal Call," (October 17, 2025). https://www.ornl.gov/file/eaw-2-proposal-call/display.

[8] Shaw, A., et al., "Participation in and Assessment of the First DNCSH Public Workshop," (2024). ORNL/TM-2024/3335. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

APPENDIX A. SURVEYS AND ATTENDEE INFORMATION

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

Attendee	Affiliation	Attendee	Affiliation
Unknown	ACC	Calvin Hopper	C. S. Engineering, Inc.
Cason Coan	Alabama Department of Public Health	Marc-Andre Charette	Cameco Corporation
Creshia Jones	Amentum	Luke Yaraskavitch	Canadian Nuclear Laboratories
Kristan Wessels		Ki Seob Sim	Candu Energy Inc
Jacob Christensen	American Nuclear Society	Jessica J Lee	Centrus Energy Corp.
Neil Cohn	AmForge	Marty Karr	
Ahmed Amin E. Abdelhameed	Argonne National Laboratory	Mark Cuzner	CICS LLC
Temitope A. Taiwo		George Kargopolov	CIS Navigation
Chang-Ho Lee		Steve Miller	Clearway
Nicolas E. Stauff		Tao He	Constellation Energy
Yan Cao		Chukai Yin	
Zhaopeng Zhong		Richard Coaxum	
Brad Rearden	Antares Nuclear	Chris Staab	CorePower
Aurelie Bardelay	ASNR	Gwen DuBois	CPSR
Luis Aguiar		Jeffrey Semancik	CT Dept of Energy & Environmental Protection
Yann Richet		Jana Bergman	CurtissWright/Scientech
Matt Brainard	AST	Assel Aitkaliyeva	DOE
Debbie MacDougall	ATA Energy	Don R Algama	
Thomas Roddey	AtkinsRealis Nuclear Secured, LLC	Elaine Beacom	
Lauren Hughes	Atlantic Council of the United States	Jean Pabon	
Dean Phillips	AVANTech, LLC	Julia Blackburn	
C.J. Hurt	Bechtel	Katie L Murphy	
Jared Filbrun		Michael Reim	
Grace Di Bartolomeo	Boston Consulting Group	Ming Tang	
Larry Wetzel	Boston Government Services	Susan Seger	
Justin Schnegelberger	Burns & McDonnell	Turner Clarke	
Grant Grothen		Brian Robinson	
Willie Clark III		Christopher Defelice	
David Livingston	BWXT	Florie Knauff	
John Justice		Franklin Brooks	
Julie Minton-Hughes		Jay Jones	
Travis Chapman		Keith Jankowski	
Caleb Robison		Kermit Bunde	
Tyler Naughton		Kimberly Gray	

Attendee	Affiliation	Attendee	Affiliation
Peter Blood	DOE	Paul Tervo	International Technology and Trade Associates
Robert Rova		Patty Riesberg	Iowa Department of Health and Human Services
Roger Nelson		Knud Ove Kjaergaard	J. POULSEN SHIPPING
Daniel A Daroy	Dominion Energy	John Bess	JFoster & Associates, LLC
Matthew B Stroud		Jesús de Omeñaca Tijero	Jóvenes Nucleares
Samantha Foster	Dominion Engineering Inc.	Andrew C Kadak	KADAK ASSOCIATES, INC.
Michael J. Keegan	Don't Waste Michigan	Chris Campbell	Kairos Power
Andrew Moore	Edlow International	Lane Boldman	Kentucky Conservation Committee
Jamie Fee	ES3	Adrien Jose Terricabras	LANL
Laura Anderson	First American Nuclear	John Quaye Quartey	
Philip Jensen		Kayla Jo Gill	
Ben Nelson	Framatome	Nicholas William Thompson	
Dave Breeding		Theresa Elizabeth Cutler	
Farshid Shahrokhi		Timothy Philip Coons	
Brandon Holden		Christopher Kirby	Lightbridge Corporation
Ru Anne Yeh		Kyle Paaren	
John Frankovich	FTI Consulting	Catherine Percher	LLNL
David Eghbali	GE Vernova Hitachi Nuclear Energy	Olamide Anthony Olabiyi	Missouri University of Science and Technology
Lon E. Paulson		Shannon Chu	N/A
Ashby Bridges	General Matter, Inc	Dylan Ward	NAC International
Hugh Nunnally	Global Laser Enrichment	Ellen O'Shea	
Thecla Fabian	GWU Alumna	Tom Best	
Ryan Mott	Hadron Energy Inc.	George Carver	
Thomas Marcille	Holtec International	Heath Baldner	
Vernon Mascarenhas	Honeywell International	James Smith	
Will Jeffries	Hull Street Energy	Ryan Archibald	
Dennis Wamsted	IEEFA	Kiera Zitelman	NARUC
Kamrynn Elizabeth Schiller	Idaho National Laboratory	Abigail Rodriguez	NASA
Kaushik Banerjee		Gregory A. Fedor	
Margaret A. Marshall		Robert J. Bruckner	
Stephanie H. Bruffey		Tyler R. Steiner	
Takanori Kajihara		Dominik Muszynski	National Centre for Nuclear Research
Javier Ortensi		Thiago Belo	NB Power
Nicolas E. Woolstenhulme		David W. Stradinger	ND DEQ
Peng Xu		Karen M. Deibert	
		Brooke M. Olson	

Attendee	Affiliation	Attendee	Affiliation
John Alexander Flood	New Brunswick Power	Sam Stephens	NRC
David Skutt	New York State Department of Health	Shana Helton	
Emanuele Fontani	Newcleo	Tex Steinfeldt	
Miroslav Sarissky		Casey Emler	
Vittorio Vaiarelli		Chris Markley	
Evan Coats	NNL	Hossein Esmaili	
Linda Carter		James Drabble	
Donna G. Hutchinson	NNSA	Jared Nadel	
Emily Himmelfarb		Kevin Roach	
Marcos Crabtree		Latischa Hanson	
Mitch Hembree		Logan Crevelt	
Tammy L Wise		Pravin Sawant	
Brandon Olinger		Reginald Augustus	
Genevieve Weaver		Robert Mathis	
RL Carbo		Zee St Hilaire	
Janell D. Anderson	North Dakota Department of Environmental Quality	JD Edion	NRG Energy, INC.
Masato Ono	NRA JAPAN	Charlotte Davis	NTS
Alex Siwy	NRC	James O’Connell	Nuclear Capital Projects Consulting
Alexander Sapountzis		Jan Boudart	Nuclear Energy Information Service
Alexis Sotomayor-Rivera		Greg Core	Nuclear Energy Institute
Andrea Johnson		Earl Hoellen	Nuclear Fuel - USA, LLC
Andrew Barto		Betsy Rivard	Nuclear Watch South
Dan Frumkin		Kris Cummings	NuScale
Daniel Forsyth		Cynthia A Costello	NYS Dept of Health
Dante Johnson		Andrew Kauk	NYS DPS
Eliezer Goldfeiz		Kelsey Amundson	OECD/Nuclear Energy Agency
Emma Duncan		Jenny Weil	Office of Sen. Whitehouse
Jeremy Munson		Abby Hargreaves	Oklo
Jeremy Smith		Seth Anderson	
Jesse Carlson		Brad Crotts	Orano Federal Services
Mauri Lemoncelli		John McEntire	
Michael Mangefrida		Bryan Rose	
Mike Call		Florian Schöner	Orano NCS GmbH
Mikhail Pellegrino		Sebastian Fels	Orano NCS GmbH
Nathan Denney		Yara Van Wijk	Orano NCS GmbH
Nathanael Hudson			

Attendee	Affiliation	Attendee	Affiliation
Jomaries Rovira	Orano	Andy Prichard	PNNL
Jay Thomas		Justin Clarity	
Nicolas Guibert		Travis Zipperer	
David Anderson		Fran Mallett	
Travis Mueller		Garrett Lavender	
Peter Vescovi		Alexandru Catalin Stafie	PSI
Matt Hendrickson	Oregon Department of Energy	Veera Gnaneswar Gude	Purdue University
Adimir Dos Santos	Oak Ridge National Laboratory	Dominic Lin	Radiant Industries
Ahmed Shama		Edward Lin	
Alex Lang		Melinda Graham	
Alex Shaw		Robby Renfrow	
Andrew Holcomb		Wei Ji	Rensselaer Polytechnic Institute
Douglas G. Bowen		Md Hossain Sahadath	
Jordan McDonnell		Ron Knief	Retired
Mark Nguyen		Vincent Esposito	Retired
Mathieu Dupont		Cameron Goodwin	Rhode Island Nuclear Science Center
Travis Greene		Alan Stevenson	Rolls-Royce
Bruce Balkcom Bevard		Nate L. Gauthier	SC Department of Environmental Services
Chris Chapman		Jared Jones	Senate EPW Committee
Cihangir Celik		Nicole E. Noelliste	Sidley Austin
Iyad Al-Qasir		Andres Guillermo Morell-Pacheco	SNL
Jason Karcz		Emma Van Moorsel	
Kemal Ramic		Jeffery Amos Greathouse	
Lam Nguyen		Matthew Scott Christian	
Lindsey D. Aloisi		Sylvia Saltzstein	
Lisa Fassino		Jason Everett Arthur Soares	
Luiz Leal		Ramon Pulido	
Veronica Karriem		Daniel Lerew	Southern Company
Walid Metwally		Lane Howard	Southwest Research Institute
Will Wieselquist		Leo Eskin	StarCore Nucly
Zain Karriem		Ron Rispoli	Stephens
Tracey Henson	Paschal Solutions, Inc.	William Dawn	Studsvik Scandpower, Inc.
Jill S. Monahan	Pennsylvania State University	Steve Hansen	TAM International
Alfred Meyer	Physicians for Social Responsibility	Galina V Tsvetkova	TAMU
Ruthanne Neely	Pillsbury Winthrop Shaw Pittman		

Attendee	Affiliation	Attendee	Affiliation
Bobbi Riedel	TerraPower	Anthony Leshinskie	Vermont Public Service Department
Dan Speaker		Zeyun Wu	Virginia Commonwealth University
Danyal Turkoglu		Timothy Franck	Virginia Tech
Michael Branco-Katcher		Cole Friedman	
Tom Drury		Courts Breeden	
Jean C Ragusa	Texas A&M University	John Stuart McCloy	Washington State University
Joy Jiang	The Breakthrough Institute	Dave Cline	Westerman Inc
Peter Seel	The Breakthrough Institute	Brooke A Conrad	
Siaka Yusuf	The Dow Chemical Company	Donald Lewis	Westinghouse Electric Co. LLC
Bob Maurer	TRISO-X	Kathryn Metzger	
Michael Cartwright		Tanya N Sloma-Delosier	
Michael Hines		Charlie Murphy	
Travis Wilson		Keith W Means	
Dallas Moser		Leah Crider	
Ryan Christopher Dreke	TVA	W. Zhou	
Volkan Seker	University of Michigan	Ori Nissim Levy	WNF-193
Alex Barzilov	UNLV	Matt Sumrall	X-energy
Ian Mance	Urenco	Nathan George	
Quentin Newell		Ryan K. Brookhart	Zachry Nuclear Engineering
Charlotta Sanders			
Olimpio Torres			

Table A-2. Submitted responses to initial survey question on the areas of importance

We are primarily R&D with needs more aligned with experiments and validation.
There are large uncertainties with the current ENDF/B-VIII dataset.
The main challenge has been validation and acceptance of new tools and methods.
At LLNL, we believe we can perfectly validate our scenarios with a simple and conservative approach. We do not place priority on sensitivity and uncertainty (S/U) methods like in TSUNAMI or Whisper and would never use them for real criticality safety work.
The NRC is requiring a larger "administrative margin" due to the lack of experiments.
Especially interested in bridging the gap in benchmark experiments for criticality safety model validation as well as HALEU supply challenges that need to be addressed to perform these critical benchmark experiments in the first place.
Section 2001 of the Energy Act of 2020 specifically directs the development of criticality benchmark data relevant to the licensing and regulation of fuel fabrication and enrichment facilities and transportation of HALEU. Creating relevant HALEU benchmarks, as Congress specifically directed, should be the focus of DNCSH.
High-quality HALEU benchmark experiments are needed in the ICSBEP Handbook.
We are interested in additional benchmarks applicable to HALEU UF_6 operations and transportation.
Identify and communicate experimental gaps to the international community.
Additional benchmarks are needed in this area (i.e., 8 to 20 w/o enriched ^{235}U, along with various other moderator/reflector materials).
Additional applicable benchmarks are always useful.
I am interested in seeing more nuclear critical experiments for validation purposes and application models relevant to these experiments as well as for transportation and storage of nuclear fuel.
The facility I work at could benefit from new benchmark data, but it isn't specific to HALEU.
I am most interested in modeling HALEU fuels.
Performance code models are essential for qualifying the fuel, and for certain fuel designs, there are insufficient empirical data to validate these models.
HALEU benchmarks are most important for writing criticality safety evaluations to get the work done.
There are few benchmarks with graphite for TRISO applications; however, for transportation, where flooding is generally assumed, the existing benchmarks generally show good coverage for these applications.
In 2016 at the Boston ANS Meeting, a paper titled "Optimization of Water-to-Fuel Ratios (W/F) in Clad Cylinder Arrays" was presented. All pellet calculations should be optimized w/this paper.
Benchmarks underpin the utility of all other areas; they are far superior in need.
Additional benchmarks are the most effective way of addressing regulatory concerns about the validation of our code, but additional guidance on validation methods (and particularly S/U tools) may be more practicable.
There are many criticality safety and reactor analysis codes, which require validation for licensing.
Work on code and nuclear data validation has been ongoing and clearly identified for several years. However, there are gaps regarding the modeling of these fissile media and the identification of key parameters. For example, in the case of TRISO, it is necessary to identify the different materials used in its fabrication (UC, UCO, etc.), their forms, and how to model them for criticality (homogeneous media, minimization of material mass for undermoderated systems, etc.). This work will also serve as a starting point for validation because it will help identify the media that need to be qualified.
Although we are already licensed, the basis for many of the things we do is primarily derived from highly enriched uranium materials. Having additional data points in the 10%–20% enrichment range may be beneficial in providing more operational margin.
Ensuring that lightweight NQA codes are available for AR developers and owner-operators in the next 5–10 years.
Benchmark experiments are of highest interest to future Antares reactors.

My area just needs more information on HALEU fuel and validating methods.
Benchmark models and validation methods are as good as the underlying nuclear data.
Nuclear data will always be at the top with benchmark data following closely.
Nuclear data gaps for advanced reactors are a real issue. NCS engineers have good validation tools already. Experiments are too expensive.
There is a lack of experimental data for higher enrichments that leaves large gaps in validation. Without proper physical validation, modeling is questionable.
Integral experiments feed into each of the other areas and therefore are the most critical.
Not a HALEU facility. We have existing validation, but benchmark similarity could be improved with planned benchmark experiments.
Reduction in calculational uncertainty will provide leaner engineered solutions and support streamlined regulatory processes.
HALEU benchmarks with Zr, C.
Accurate nuclear data can be used to generate potential “errors” and apply uncertainty values over a range of neutron energy levels; benchmark experiments can be used to validate the nuclear data.
I prioritized additional benchmark experiments first because current validation is limited by gaps—particularly for HALEU systems in unmoderated, slightly moderated, and reflected configurations. These gaps directly affect confidence in criticality safety evaluations for new fuel forms. Second, application models with HALEU fuel are increasingly relevant across advanced reactor and fuel cycle projects, making their validation essential. Third, validation methods in NCS provide the framework to apply benchmark data meaningfully. Fourth, supplemental analysis tools like TSUNAMI enhance but cannot replace benchmark-driven validation. Finally, although nuclear data are foundational, their uncertainties are best addressed via benchmark comparison and sensitivity analysis.
From published literature, I believe getting more benchmark experiments is the most important among the five listed areas. However, I do not work in a fuel facility.
New benchmarks help the ICSBEP/IRPhEP Handbooks also looking into other types of experiments that would benefit the NCS community.
The areas I am most interested in are additional benchmark experiments and nuclear data to support upper subcritical limit calculations/reducing margins through uncertainty reduction.
The facility most relevant to me is the SPRF/CX facility, which I believe would benefit from additional benchmark experiments.

Table A-3. Submitted responses to initial survey question on feedback on the ORNL/TM-2025/3744 report

The lack of benchmark data could affect the information presented.
Reactor vendors are proposing to ship back their HALEU fuel in core. Does EOL composition matter at all?
The results of the study are relatively straightforward. I would be interested in more discussion about hypothetical critical experiment designs that can be utilized to meet the short gaps in benchmark data needed for HALEU fuel types.
Section 3 (and Table 50 in particular) is very good and indicative of the lack of benchmarks there are for certain fuel types. However, cases with metal reflection (as would be found in casting operations) would also be useful.
The ICSBEP benchmarks are not identified in the report. Experimental needs require greater elaboration.
It would be interesting to see plots of c_k by type of experiment for each application. For example, what are the experiments or, more broadly, the type of experiments that have the highest c_k for each application tested. In this report, we only see the numbers above or below 0.8 and 0.9. I would appreciate more details. This could give insight into what are the most similar experiments, thus providing indication of what type of experiments should be designed to increase the number of similar experiments and fill the gap. This work can also be done manually by anyone because we have the application models available on the repository, so it's fine.
I was happy to see that the sensitivity coefficients that I computed for DICE were used. This was the first information I had about the great decision to make the application case sensitivity files available!
I would greatly appreciate involvement of industry if generic and nonproprietary application models or relevant details for their application are shared with ORNL researchers to be populated under Application Models Repository to be made publicly available.
Page 52 states that it is "very likely" that one unmoderated fuel type would provide high similarities for other unmoderated fuel assemblies. Does this imply that benchmarks only need to be developed for one fuel type? Or are there other concerns that need to be considered, such as geometry, materials, and enrichment?
The presence of minor actinides in metal fuel could significantly affect criticality and hence fabrication approach. Seemingly not addressed.
Focus on novel materials that lack validation data.
Great report. Benchmarks seem needed to support high burnup (150 GWd/MT or more) for burnup credit assessments.
I would like to see the calculated nuclear data sensitivities for more materials for these systems. I suspect that there are many more materials in need of improved nuclear data beyond the HALEU fuel itself.
Expansion of the methods to include other codes/cross sections.
Impact to engineering design, procurement, and construction of these facilities.
None based on my first glance. NCS issues are mostly at-the-floor safety issues. Validation is a small concern compared with this.
What is mentioned in Section 4 regarding potential poisons/absorbers (structural or added) during shipping/assembly and their effects on benchmark similarity sounds of interest.
Unsure, as I have little time at present to fully read and comment on the document due to heavy workload.
The focus area is quite comprehensive from my view.
Fuel cycle facilities and UF_6 transportation packages are covered briefly in ORNL/TM-2024/3248.
Overall, the analysis approach in the report is solid in terms of the fuel forms considered and the analysis leading to benchmark gaps. I would be curious about critical configurations associated with uranium-bearing fluoride salts—FLiBe is a popular fuel salt option being considered for molten salt reactors.

Table A-4. Submitted responses to initial survey question on workshop focus areas

HALEU availability timelines from USG.
Impurity of HALEU.
NRC facility needs should be differentiated from DOE facility needs. Are there design strategies for various aspects of fuel cycle facilities (FCFs) based on standards requirements (e.g., moderator control, absorbers)?
I can't think of a way that FCFs and UF_6 transport could be covered more thoroughly, but I need to review and think about it more.
I would like to see more analyses of manufacturing, transportation, and storage of fuels for molten salt fuel cycles.
Ensured and shifted levels of criticality during shipment seem to be an important topic. eVinci and other reactors are proposed to be shipped fueled (both at BOL and EOL) and therefore they won't be brought critical via fuel addition). Is it interesting to be able to measure in different ways shifts in criticality and the approach to critical process?
The importance of cross-office collaboration within DOE. For example, Office of Science resources put to use to address gaps and needs within the Office of Nuclear Energy and how these resources are prioritized.
I would be interested in UF_6-specific areas, including transport, that may aid in the modeling and licensing of facilities and packages.
Liquid fuels loaded with HALEU levels of fissile material—criticality, reconfiguration, volatilization.
Supply chain for materials, construction of these facilities.
How to get involved for general NCS support beyond validation.
Ease of processing for ultimate disposal.
I would appreciate more linking with the first workshop. How does this compare with the first workshop? Are we looking at completely different needs, parallel needs, same needs?

Table A-5. Submitted responses to post-workshop feedback survey

Rating	Open Response	Assigned Categories
3	UF_6 conversion.	Applications and Designs
3	Not just increase the availability of models and tools for using benchmarks in validation activities but provide training to use them. Not everyone can perform sensitivity/c_k analyses, let alone interpret them (many that do use them do not fully understand the capabilities or limitations). I understand why they are useful for some proposal submissions, but not everything can be grouped into a "sensitivity bucket." We want to enable innovation, not hinder it. So, if we're asking for things in proposals and funded work, we need to provide the means to support this (not just throwing files onto a website and saying, "There you go").	NCS Methodology
4	Validation priorities for HALEU fuel include standardized fabrication and QA/QC with advanced monitoring, material property data with safety and criticality benchmarks, and advanced manufacturing with robotics plus harmonized standards, logistics, and safeguards.	Regulations
4	Completion of the experiments and reporting of the results.	Experimental Needs
4	The workshop introduces most topics of primary interest. In addition, I would suggest paying attention to the following topics: 1. Alternatives to replace in-reactor experiments to generate datasets for validation. 2. Critical assembly tests with U-Pu-Zr and U-MAs-Zr fuels for fast reactors.	Experimental Needs
4	Accurate nuclear data are essential.	Experimental Needs
3	Benchmarks may also need to include transient experiment data. Accurate prediction of the dynamic response of the system (accident scenarios) is also critical in licensing and operating facilities with HALEU fuel.	Experimental Needs
4	Proliferation, safety, and security issues.	Regulations
2	Dynamic burnup calculations being standardized.	Back End
5	N/A	N/A
4	Existing experiment platforms that can be adapted to meet validation needs; this would promote a larger number of experiments.	Experimental Needs
4	N/A	N/A
4	There should be a proposal to investigate how the waste and contamination from the whole project can be cleaned up and avoided in the future. Until then, polluting and radio-contaminating activities such as uranium mining, milling, transformation to UF_6, enrichment, chemical transformation to UO_x, fuel fabrication, fission to boil water and supply medical isotopes and tritium for the US War Department, defueling reactor vessels, pool storage of spent fuel, and the creation of independent spent fuel storage installations should NOT go forward. Also, I got some concepts from the workshop. One of several that really impressed me was Iyad Al-Qasir's investigation of neutron moderators. Sometimes something that comes out of the billions wasted on the US War Department's life-threatening research turns up a really interesting study.	N/A

Rating	Open Response	Assigned Categories
4	The higher enrichment of HALEU significantly changes criticality safety considerations compared with the criticality safety considerations for traditional LEU. So, I think that we should focus on new benchmark critical experiments that are directly relevant to HALEU, such as experiments with different fuel forms (e.g., uranium oxycarbide [UCO] TRISO particles, uranium salts, uranium metal, etc.), different geometries (heterogeneous and homogeneous configurations), and different neutron energy spectra (thermal and fast). Then, benchmark data need to be validated, and computational codes and nuclear data libraries need to be refined and adjusted to the new fuel forms. I think we should not forget that demonstrating subcriticality is important in the whole fuel lifetime: manufacturing, storage (dry and potential wet storage options, with an emphasis on criticality safety and thermal management), transportation, AND the back end (i.e., we shall also ensure the safe handling of irradiated fuel!). We need to bear in mind that the higher enrichment and potential for higher burnup of HALEU fuel will affect the characteristics of spent nuclear fuel, necessitating validation of new waste management and disposal strategies, validation of shielding requirements and operational procedures, etc. Additionally, validation and benchmarking should cover potential accident scenarios, such as water ingress into a dry storage or transport container, to ensure that the systems remain subcritical under all foreseeable conditions, either normal or accidental. We may also want to focus on validating the manufacturing processes for HALEU fuel elements, such as the pressing and sintering of pellets, or the formation of TRISO compacts and pebbles. I am particularly concerned about benchmarking the properties of the final product, such as density, grain size, and homogeneity. These are important parameters for designers and for computer code users to correctly simulate and predict the behavior of HALEU in its different forms and geometries under different conditions and scenarios. Additionally, despite this not being my main area of domain, it might also be interesting to conduct experiments to validate the compatibility of HALEU fuel forms with cladding and other structural materials under various conditions to ensure long-term performance and integrity. I hope at least some of these ideas are helpful for DNCSH and for future workshops.	Experimental Needs
3	Training and workforce development: ICSBEP evaluations have many requirements, and historical evaluations bring a unique set of challenges for an evaluation. It is important that evaluators understand the	Regulations

Rating	Open Response	Assigned Categories
	requirements and are provided with resources to assist and collaborate with experienced evaluators.	
4	I would like to see more on UF_6 HALEU.	Applications and Designs
4	Investigate simulation options where validation benchmark gaps exist.	NCS Methodology
2	TRISO systems with low-enrichment particles (2%–5%). These systems may prove more reactive due to heterogeneous effects.	Applications and Designs
4	I was not able to join the entire webcast due to a different meeting running well over its intended time frame. Additionally, because I am new to this space, I will need to review much of what I saw yesterday and figure out a lot of what it means. Hopefully I will be able to give more meaningful feedback in the future.	N/A
4	N/A	N/A
4	LWR/BWR: 11 × 11 fuel lattice LEU+ (8%) enrichment UO_2—w/poison considerations (B, Cd, Cl) Accident-tolerant fuel cladding High-gadolinium content fuel (10% or higher) Simulated high void fraction (>70%) lattice Sodium-cooled fast reactor (HALEU): U-metal fuel pins / lattice U-10Zr alloy fuel pins / lattice	Applications and Designs
5	N/A	N/A
4	Improved validation coverage for HALEU and TRISO fuel without water moderation.	Applications and Designs
4	Uranium nitride production—more data on fabrication and handling at HALEU enrichments. Benchmark experiments in the 10%–20% enrichment range. This gap is critical for validating facility criticality safety and scaling to commercial operations. Yttrium hydride (YH) benchmarks. Because YH is an emerging moderating material, YH data would support new advanced reactor concepts and complement existing ZrH knowledge.	Applications and Designs
4	The permit application processes and validation requirements are going through significant changes. Manufacturers of small modular reactor units and end users will need to understand when and how the NUREG (i.e., CR 7311 and others) changes will be adopted into a formal CR format and how the licensing process will be affected. Can your team provide some clarity on these items?	Regulations
5	In my view, manufacturing and fabrication should be the most important issues for the second DNCSH proposal. The as-built data deserve great attention. All as-built data should be available with a description of the equipment that performs the analyses, its accuracy, calibration, etc. This is fundamental to making reliable uncertainty analyses.	Experimental Needs
5	Benchmark experiments with beryllium-based moderators.	Experimental Needs

Rating	Open Response	Assigned Categories
5	It would be good to know some actual facility needs if those could be made available.	Applications and Designs
4	The end state should always be kept in mind from fabrication to disposal or reprocessing.	Back End
5	We should definitely be focused on developing criticality benchmarks relevant to HALEU transportation, manufacturing, and fabrication applications. Although there are nuclear data needs for other applications (e.g., advanced moderators), I do not think that these needs should be a focus for DNCSH.	Experimental Needs
5	Four topics come to mind: 1) Shielding and Source Term Validation: Benchmark neutron and gamma source terms, dose rates, and shielding effectiveness for HALEU processing facilities to ensure worker protection and regulatory compliance. 2) Process Monitoring and Safeguards Integration: Validate nondestructive assay techniques and process monitoring approaches tailored for HALEU fuel forms, supporting both facility operations and safeguards requirements. 3) Spent Fuel and Waste Management: Benchmark decay heat, radiation fields, and isotopic composition predictions for HALEU spent fuel to inform storage, transport, and disposal safety analyses. 3) Nuclear Data for Burnup and Depletion Applications: Improve fission yield data, capture cross sections, and decay data relevant to HALEU enrichment levels to enable accurate depletion, isotopic inventory, and burnup credit analyses across the fuel cycle. Other topics that are relevant (I believe they have been included in previous call!!) 1) Nuclear Data and Cross Section Validation: Ensure accurate nuclear data for ^{235}U, ^{238}U, and minor isotopes at enrichments up to ~20%, including resonance parameter evaluation and integral benchmark validation relevant to HALEU systems. 2) Criticality Safety Benchmarks: Develop and analyze benchmarks that represent HALEU handling and storage configurations (powder, pellets, assemblies, canisters) to validate methods used in facility safety analyses. 3) Thermal Scattering and Material Properties: Improve measurements and evaluations of thermal scattering laws (TSLs) for key materials used in HALEU fuel fabrication (e.g., UO_2, U_3Si_2, metallic uranium alloys, cladding and moderating materials). 4) Systems Involving Fluorine Chemistry: Strengthen nuclear data and benchmark validation for fluorine-containing systems (e.g., UF_6 handling in enrichment facilities, molten fluoride salts such as FLiBe or FLiNaK, systems including HF). This includes improved cross sections for ^{19}F, thermal scattering treatments,	Experimental Needs

Rating	Open Response	Assigned Categories
	and integral experiments representative of HALEU fuel cycle operations.	
4	HALEU fuel—enrichment, mentalization, TRISO manufacturing, fuel element design and supply chain, fuel qualification. The list goes on and on.	Applications and Designs
4	Development of experiments to support validation efforts.	Experimental Needs
4	I am interested in ongoing TSL work, chloride salt integral experiment benchmarks, and nuclear data work related to chloride salts.	Experimental Needs
3	Sharing standards for HALEU fuel management with regulatory agencies.	Regulations
5	A key area of focus should be the development of methods for validation and, by extension, for gap and coverage analysis. In current practice, gaps are typically identified using engineering judgment and c_k-based analysis; however, advanced approaches could better leverage existing validation data. Methods that balance the number of benchmarks, their similarity indices (e.g., c_k or alternatives), and required safety margins offer a path to more rigorous justification of coverage and clearer identification of benchmark needs.	NCS Methodology
4	List all appropriate existing benchmarks.	NCS Methodology
4	TRISO fuel with different packing fractions.	Applications and Designs
4	Using c_k thresholds of 0.8 and 0.9 is good, but I would like to see some more qualification of representativity that isn't so black and white (and focuses on nuclide and energy) to drill further into the gaps. A characterization of what didn't work would be informative, especially for some of the uranium fluoride work. Tell us what isn't worth trying to look into!	NCS Methodology
4	Facility operations.	Applications and Designs
4	After thinking/studying more about the DNCSH project objectives, I did more research. My offerings at this stage of the project are likely already considered. Regardless, the following are my thoughts about the need for physicochemical and critical experiments to fill gaps in the use of HALEU and new fuels. Perhaps some of my thoughts will reinforce current objectives and, if not, at least stimulate further thought. Listed below are suggested priorities for experiments with various fuel candidate materials based on the notes and references. Candidate Materials Priority Notes/References UC High Limited benchmarks (mostly fast spectrum, experimental reactors). UCO High Sparse benchmarks; relevant for TRISO particle fuel work. UCl_3 High Very limited/no benchmarks in ICSBEP; high relevance for molten salt fuel concepts. UF_4 High Limited benchmark data; considered for MSR fuel cycle chemistry.	Experimental Needs

Rating	Open Response	Assigned Categories
	UH_3 High Unstable material, very limited benchmarks; critical safety concern. U-Mo High Some research reactor benchmarks; HALEU application interest. UN High Sparse coverage, some fast reactor benchmarks. U-Zr Medium Benchmarks for U-ZrH exist (TRIGA) but are limited for metallic U-Zr alloys. ZrB_2 IFBA Medium IFBA benchmarking indirect; boron benchmarks exist but are not coating-specific. UO_2 Low Well benchmarked; standard LWR fuel, including HALEU studies. U-$ZrH_{1.6}$ Low Well covered by TRIGA benchmarks in ICSBEP. U metal Low Extensively benchmarked in ICSBEP (fast and thermal systems). Also, I have listed the perceived near- and long-term prioritizations for reactor development/deployment. • Near-Term Priorities: o HALEU UO_2 + ZrB_2 IFBA: Mature LWR fuel with IFBA coating; benchmarked and licensable. o TRISO UCO: High retention, HTGR/FHR ready; irradiation data available. o U-10Mo: High density, research reactor pedigree, HALEU microreactors. o U-Zr metal alloy: Heritage from EBR-II/FFTF; fast spectrum applications. o U-$ZrH_{1.6}$: Strong negative temperature feedback; proven TRIGA use. • Long-Term Priorities: o UN (^{15}N-enriched): High conductivity and density; supply chain/licensing challenges. o UC: High actinide density; swelling/compatibility issues. o Molten salt fuels (UF_4, UCl_3): System-level potential; corrosion/licensing gaps. o Pure U metal/alloys: Lower dimensional stability vs. U-Zr/U-Mo; weaker dataset. o UH_3: Unstable/pyrophoric; not a practical fuel.	