U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

Nuclear Energy Advisory Committee

April 30, 2024
The Honorable William D. Magwood, IV, Chair

U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

Opening Remarks

Dr. Kathryn Huff, Assistant Secretary for Nuclear Energy
The Honorable William D. Magwood, IV, Chair

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Office of Nuclear Energy Update

Dr. Kathryn Huff, Assistant Secretary
Office of Nuclear
U.S. Department of Energy

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NE Reorganization Update

Dr. Kathryn Huff, Assistant Secretary
Office of Nuclear
U.S. Department of Energy

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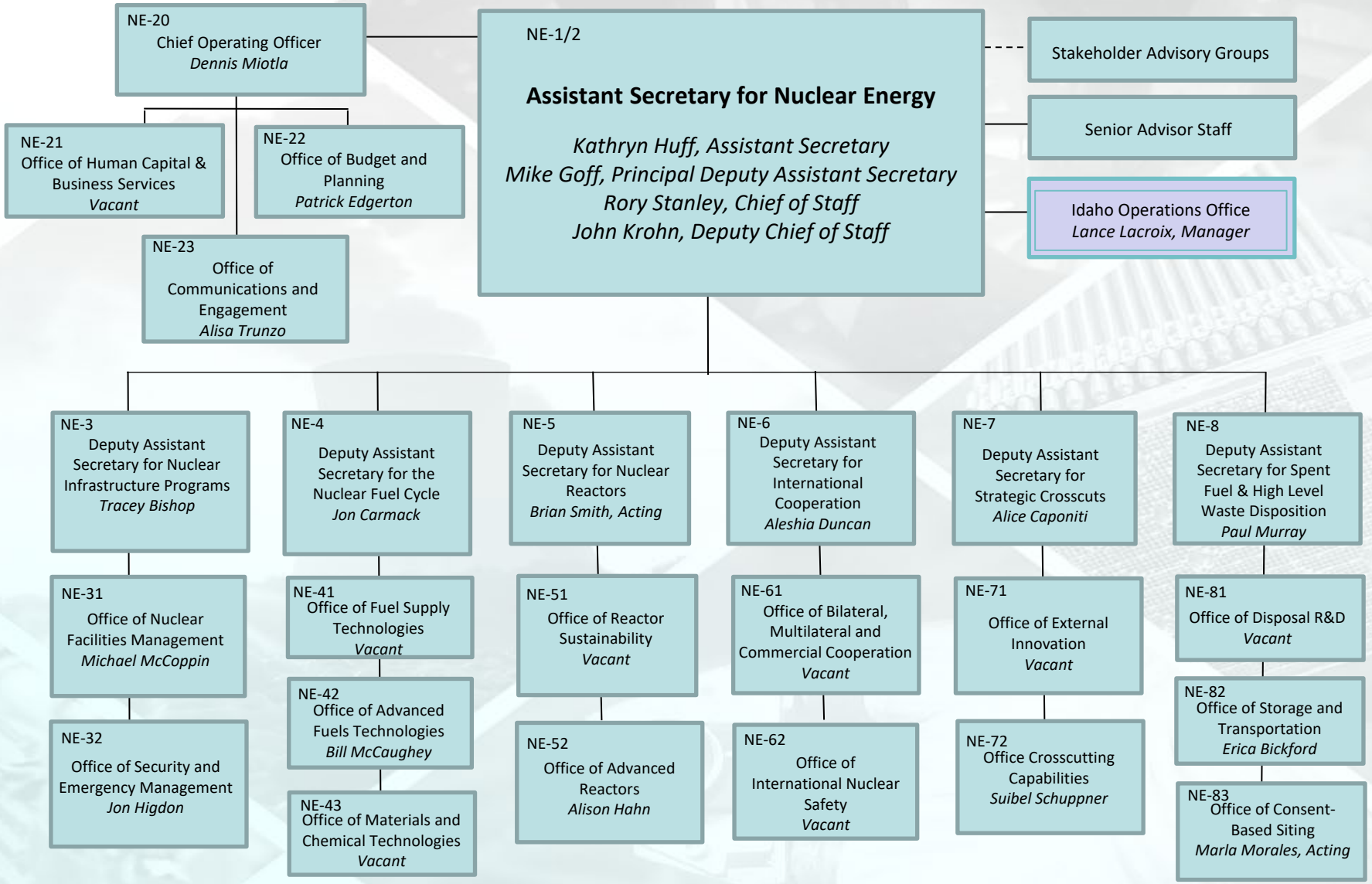
April 7, 2024



Finalized Organization Highlights – Effective April 7, 2024

- Creation of a new DAS-level organization – Office of Strategic Crosscuts, NE-7
  - Office of External Innovation, NE-71
  - Office of Crosscutting Capabilities, NE-72

- Rescoping the activities in the current DAS-level organization – Office of Nuclear Reactors, NE-5
  - Office of Reactor Sustainability, NE-51
  - Office of Advanced Reactors, NE-52

- Additional Changes:
  - Retitling of NE-4 to the Office of Nuclear Fuel Cycle and creation of new office – Office of Fuel Supply Technologies, NE-41
  - Retitling of NE-6 to the Office of International Cooperation
  - Retitling of NE-8 to the Office of Spent Fuel and High-Level Waste Disposition and separation of NE-82 to create to separate offices – Office of Storage and Transportation, NE-82 and Office of Consent-Based Siting, NE-83
  - Retitling of NE-32 to the Office of Security and Emergency Management

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NE FY25 Budget

Dr. Kathryn Huff, Assistant Secretary
Office of Nuclear
U.S. Department of Energy

FY 2025 Office of Nuclear Energy Budget Request Program Level Summary

$Thousands	FY 2023 Enacted - Comparable	FY 2024 Enacted - Comparable	FY 2025 Request	FY 2025 Request vs FY 2024 Enacted $	FY 2025 Request vs FY 2024 Enacted %
University and Competitive Research Programs	130,276	140,000	143,400	3,400	2%
Reactor Concepts RD&D	*279,872*	*136,812*	*88,300*	(48,512)	-35%
Fuel Cycle Research and Development	*404,900*	*428,500*	*446,690*	18,190	4%
Nuclear Energy Enabling Technologies	*88,413*	*88,264*	*105,100*	16,836	19%
Advanced Reactors Demonstration Program	*288,315*	*315,424*	*218,248*	(97,176)	-31%
ORNL Nuclear Facilities O&M	20,000	-	-	-	0%
INL Facilities Operations and Maintenance	318,924	326,000	333,922	7,922	2%
16-E-200 Sample Prep Lab	7,300	-	-	-	0%
Infrastructure	*346,224*	*326,000*	*333,922*	*7,922*	*2%*
Idaho Sitewide Safeguards and Security	150,000	160,000	150,000	(10,000)	*-6%*
International Nuclear Energy Cooperation	3,320	3,150	8,000	4,850	*154%*
Program Direction	81,680	86,850	97,000	10,150	*12%*
	1,773,000	1,685,000	1,590,660	(94,340)	-6%
Program Transfers (OCED/SC)	79,474	-	-	-	
Nuclear Energy Executed	1,773,000	1,685,000	1,590,660	(94,340)	-6%
NR ATR Transfer	99,747	92,800	-	(92,800)	-100%
Nuclear Waste Fund Oversight	10,205	12,040	12,040	-	0%

FY 2025 Office of Nuclear Energy Budget Request Control Level Detail

	FY 2023 Enacted - Comparable	FY 2024 Enacted - Comparable	FY 2025 Request	FY 2025 Request vs FY 2024 Enacted $	FY 2025 Request vs FY 2024 Enacted %
SBIR/STTR	26,673	29,078	25,340	(3,738)	-13%
Technology Commercialization Fund	8,602	7,710	6,338	(1,372)	-18%
University Led Research & Development	59,001	64,360	62,992	(1,368)	-2%
University Infrastructure	12,000	12,000	12,000	-	0%
NEUP, SBIR/STTR, and TCF	106,276	113,148	106,670	(6,478)	-6%
University Nuclear Leadership Program (UNLP)	6,500	6,630	8,500	1,870	28%
University Fuel Services	17,500	20,222	28,230	8,008	40%
University and Competitive Research Programs	**130,276**	**140,000**	**143,400**	**3,400**	**2%**
Advanced SMR RD&D	164,400	9,500	-	(9,500)	-100%
LWR Sustainability	44,400	44,500	35,000	(9,500)	-21%
Advanced Reactor Technologies	59,072	67,300	43,800	(23,500)	-35%
Integrated Energy Systems	12,000	15,512	9,500	(6,012)	-39%
Reactor Concepts RD&D	***279,872***	***136,812***	***88,300***	***(48,512)***	***-35%***
Mining, Conversion, and Transportation	2,000	1,500	2,000	500	33%
Material Recovery and Waste Form Development	44,500	54,500	38,500	(16,000)	-29%
Accident Tolerant Fuels	96,000	92,000	97,900	5,900	6%
Fuel Cycle Laboratory R&D	15,000	16,000	15,000	(1,000)	-6%
Next Generation Fuels	47,400	63,000	43,290	(19,710)	-31%
Adv Nuc Fuel Availability	100,000	99,500	150,000	50,500	51%
Used Nuclear Fuels Disposition R&D	47,000	47,000	47,000	-	0%
Integrated Waste Management System	53,000	55,000	53,000	(2,000)	-4%
Fuel Cycle Research and Development	***404,900***	***428,500***	***446,690***	***18,190***	***4%***
Advanced Materials and Manufacturing Technologies	9,610	10,582	23,000	12,418	117%
Advanced Sensors and Instrumentation	6,500	4,582	9,000	4,418	96%
Nuclear Energy Advanced Modeling and Simulation	27,500	27,500	28,600	1,100	4%
Nuclear Science User Facilities	34,750	34,500	34,500	-	0%
Gateway for Accelerated Innovation in Nuclear	10,053	11,100	10,000	(1,100)	-10%
Nuclear Energy Enabling Technologies	***88,413***	***88,264***	***105,100***	***16,836***	***19%***

	FY 2023 Enacted - Comparable	FY 2024 Enacted - Comparable	FY 2025 Request	FY 2025 Request vs FY 2024 Enacted $	FY 2025 Request vs FY 2024 Enacted %
National Reactor Innovation Center	67,000	63,000	31,000	(32,000)	-51%
Demonstration 1 (X-Energy)	30,000	30,000	-	(30,000)	-100%
Demonstration 2 (Natrium)	30,000	30,000	-	(30,000)	-100%
Risk Reduction for Future Demonstration	120,000	137,222	142,500	5,278	4%
Regulatory Development	12,065	14,030	15,000	970	7%
Advanced Reactor Safeguards and Security	9,250	9,172	11,000	1,828	20%
23-E-200, LOTUS, INL	20,000	32,000	18,748	(13,252)	-41%
Advanced Reactors Demonstration Program	***288,315***	***315,424***	***218,248***	***(97,176)***	***-31%***
ORNL Nuclear Facilities O&M	20,000	0	-	-	0%
INL Facilities Operations and Maintenance	318,924	326,000	333,922	7,922	2%
Construction					
16-E-200 Sample Prep Lab	7,300	0	-	-	0%
Infrastructure	***346,224***	***326,000***	***333,922***	***7,922***	***2%***
Idaho Sitewide Safeguards and Security	150,000	160,000	150,000	(10,000)	-6%
International Nuclear Energy Cooperation	3,320	3,150	8,000	4,850	154%
Program Direction	81,680	86,850	97,000	10,150	12%
Outyear Planning Wedge / Unallocated	-	-	-	-	0%
Nuclear Energy Enacted	**1,773,000**	**1,685,000**	**1,590,660**	**(94,340)**	**-6%**
NR ATR Transfer	99,747	92,800		(92,800)	-100%
Nuclear Waste Fund Oversight	10,205	12,040	12,040	-	0%

Nuclear Energy FY 2025 Budget Highlights

- NE's FY 2025 budget request reflects a decrease of 6%, $94M, below the FY 2024 enacted appropriation.
- $150M (+$50M) is requested to continue near-term production of HALEU from limited DOE uranium inventories and the HALEU enrichment facility in Piketon, Ohio.
- $23M (+$12.4M) is requested for Advanced Materials and Manufacturing Technologies R&D to support advanced reactor designs and deployment. Includes $6M for high priority advanced reactor supply chain issues.
- $142.5M (+$5.3M) is requested for the ARDP Risk Reduction for Future Demonstration awards.
- $143M (+$3.4M) is requested for University and Competitive Research Programs, including funding university reactor fuel procurement and disposition, competitively awarded R&D projects, undergraduate scholarships, and graduate fellowships.
- $8M (+$4.7M) is requested to support ongoing deployment of U.S. technology clean-energy reactors in Africa, Asia and Eastern Europe.

Nuclear Energy FY 2025 Budget Highlights

The NE Budget proposes six new budget lines to provide enhanced visibility and clarity for ongoing Nuclear Energy activities and the Department's crosscutting R&D efforts. Crosswalk tables can be found at the end of the slide deck.

1. **Integrated Energy Systems (Reactor Concepts RD&D),** previously included in the discontinued Crosscutting Technology Development line, supports R&D to expand the role of nuclear energy by developing technologies that support electrical, thermal, and chemical energy pathways that deliver nuclear energy both on and off the electricity grid.
2. **Next Generation Fuels (Fuel Cycle R&D),** previously included in the discontinued TRISO and Graphite Qualification line, supports industry with financial assistance and lab-based research and development to continue to drive fuel innovation over the long term. It lays the groundwork for fuels that significantly outperform today's fuel, focusing on long-term, high-risk, high-reward fuel concepts.
3. **Advanced Materials and Manufacturing Technologies (Nuclear Energy Enabling Technologies, NEET),** previously included in the discontinued Crosscutting Technology Development line, focuses on innovative research to accelerate the development, qualification, demonstration, and deployment of advanced materials, manufacturing technologies, and supply chain capacity.
4. **Advanced Sensors and Instrumentation (ASI),** previously included in the discontinued Crosscutting Technology Development line, performs research and development of advanced sensors and instrumentation to expand measurement capabilities to address critical technology gaps.
5. **Gateway for Accelerated Innovation in Nuclear (GAIN),** previously funded as a crosscutting activity across multiple NE subprograms, facilitates access for industry to national laboratory knowledge and capabilities to rapidly advance the development and deployment of nuclear energy, and to communities looking to investigate options for deployment of nuclear energy power sources.
6. **International Nuclear Energy Cooperation (INEC),** previously funded within Program Direction, leads NE international engagement through the development, coordination, and implementation of U.S. civil nuclear policy and integrates it with NE's technical programs.

Nuclear Energy R&D Program

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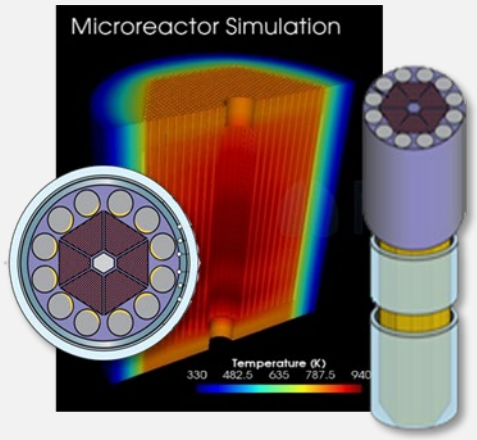
Reactor Concepts RD&D

Mission: Conduct R&D on existing and advanced reactor designs and technologies to enable industry to address technical challenges while maintaining the existing fleet of nuclear reactors, promoting the development of a robust pipeline of advanced reactor designs and technologies and associated supply chains, and progressing these advanced reactor designs and technologies towards demonstration.

NuScale Power Module



Conceptual microreactor core simulation Courtesy of Idaho National Laboratory

FY 2025 Planned Accomplishments

- Conduct research to support the existing commercial nuclear fleet including the development and demonstration of artificial intelligence and machine learning technologies to improve and automate monitoring and control of plant systems and tie real-time plant information to automated work activities at operating plants to enhance plant performance during long term operation.
- Complete fabrication of fuel and components for the Microreactor Applications, Research, Validation and Evaluation (MARVEL) test platform to enable demonstration of microreactor technologies and end-use applications.
- Develop and test thermal distribution components and systems for a variety of heat transfer fluids as necessary for system modeling and design of integrated energy systems.

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Reactor Concepts RD&D	***279,872***	***136,812***	***88,300***	***(48,512)***	***-35%***

Fuel Cycle R&D

Mission: Conduct early-stage applied research and development on advanced fuel cycle technologies that have the potential to accelerate progress on managing and disposing of the nation's spent fuel and high-level waste, improve resource utilization and energy generation, reduce waste generation, and limit proliferation risk.

FY 2025 Planned Accomplishments

- Continue to support the accident tolerant fuel concepts under development by the three fuel vendor teams under cooperative agreements with the Department.
- Continue near-term production of HALEU from limited DOE uranium inventories and the HALEU enrichment facility in Piketon, Ohio.
- Continue EBR-II fuel recycling efforts to provide 1,200 Kg HALEU.
- Initiate simplified uranium recovery lab-scale demonstration to target recycling of HALEU containing fuels.
- Next Generation Fuels lays the groundwork for advanced fuels that significantly outperform today's fuel, focusing on long-term, high-risk, high-reward fuel concepts.
- Continue funding for and consultations and cooperation with communities, States, and Tribes exploring the consent-based siting process and federal consolidated interim storage.

	FY 2023 Enacted - Comparable	FY 2024 Enacted - Comparable	FY 2025 Request	FY 2025 Request vs FY 2024 Enacted $	FY 2025 Request vs FY 2024 Enacted %
Mining, Conversion, and Transportation	2,000	1,500	2,000	500	33%
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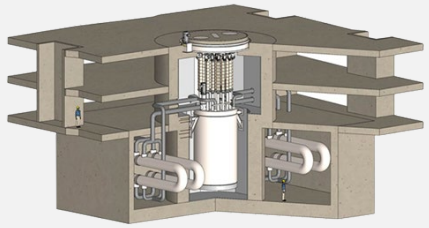
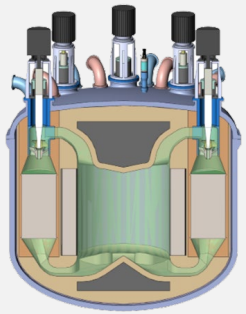
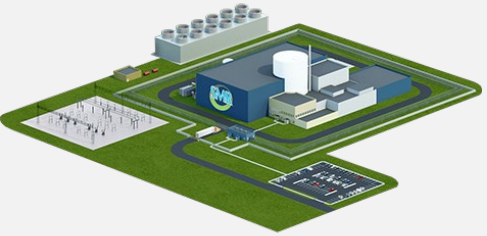
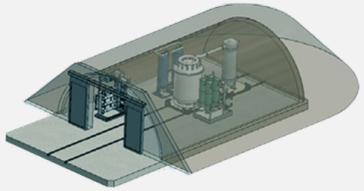
Advanced Reactor Demonstration Program

Mission: The Advanced Reactor Demonstration Program (ARDP) focuses Departmental and non-federal resources on the design, licensing, and construction of demonstration reactors in the near- and mid-term that are safe and affordable to build and operate.









FY 2025 Planned Accomplishments

- Complete construction of the DOME test bed to enable development and demonstration of microreactor technologies.
- Initiate operation of MSTEC at INL to close a vital experimental gap for MSRs.
- Support execution of the five Risk Reduction projects per established project plans.
- Continue to coordinate with industry and the NRC to identify and resolve technology gaps and high impact challenges associated with advanced reactor regulation, including the Advanced Nuclear Energy Cost-Share Grant Program.
- Continue research to address material control and accounting, physical protection, and cybersecurity requirements for reactors built in the U.S.
- 23-E-200, LOTUS: Initiate construction related activities.

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Advanced Reactors Demonstration Program	***288,315***	***315,424***	***218,248***	***(97,176)***	***-31%***

Infrastructure

Overview: Infrastructure consists of the Idaho National Laboratory (INL) Facilities Operations and Maintenance (IFM), Oak Ridge National Laboratory (ORNL) Nuclear Facilities Operation and Maintenance, and Construction subprograms.

FY 2025 Planned Accomplishments

- The ORNL Nuclear Facilities Operations and Maintenance subprogram is fully funded in the Office of Science FY 2025 Request.
- Maintain the availability and reliability of the Advanced Test Reactor and Materials and Fuels Complex facilities, including repair and replacement of end-of-life components and systems.
- Initiate preliminary conceptual designs for modernizing end-of-life fuel research and development capabilities.
- Continue regulatory compliance program management, including meeting INL Site Treatment Plan milestones.
- The Construction subprogram reflects completion of the Sample Preparation Laboratory project capital funding profile.

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INL Facilities Operations and Maintenance	318,924	326,000	333,922	7,922	2%
Construction					
16-E-200 Sample Prep Lab	7,300	0	-	-	0%
Infrastructure	***346,224***	***326,000***	***333,922***	***7,922***	***2%***

International Nuclear Energy Cooperation

Overview: Lead DOE's international civil nuclear engagement with U.S. industry and foreign partners, including the coordination of NE's international nuclear technical activities with the implementation of U.S. nuclear energy policy.

FY 2025 Planned Accomplishments

- Support Front-End Engineering Design studies for U.S. nuclear builds in foreign markets.
- Continue support for nuclear safety in Armenia and Ukraine, including emergency support due to the ongoing hostilities in Ukraine.
- Continue deployment of Clean Energy Training Centers to inform small and emerging nuclear states of U.S. nuclear technology within clean energy systems.
- Increase U.S. technical presence through bilateral nuclear cooperation particularly in Eastern Europe, the Baltic States, Southeast Asia, and the Americas, including workforce capacity building, academic and professional training, joint studies, and regional technical events.
- Leverage U.S. sponsorship of subject matter experts in international organizations to advance U.S. nuclear equities.

	FY 2023 Enacted - Comparable	FY 2024 Enacted - Comparable	FY 2025 Request	FY 2025 Request vs FY 2024 Enacted $	FY 2025 Request vs FY 2024 Enacted %
International Nuclear Energy Cooperation	3,320	3,150	8,000	4,850	154%

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Questions

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Tribal Engagement Update & Overview

John Krohn, Deputy Chief of Staff
Office of Nuclear of Energy
U.S. Department of Energy

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Questions

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Break

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NEAC 2024:
Used Nuclear Fuel and High Level Waste

Mr. Paul Murray, Deputy Assistant Secretary
Spent Fuel & Waste Disposition
U.S. Department of Energy

TIMELINE HISTORY OF DEEP GEOLOGIC REPOSITORY PROGRAM

1950s

Active investigation began on the concept of mined geological repositories for disposal of radioactive waste

1970s

U.S. studied feasibility of reprocessing commercial spent nuclear fuel to extract plutonium; approach later canceled, leaving disposal as primary option for managing radioactive waste.

1980

DOE issued the final environmental impact statement: *Management of Commercially Generated Radioactive Waste.*

1981

DOE issued a record of decision announcing its determination to pursue mined geologic disposal for spent nuclear fuel and high-level radioactive waste.

1982

Congress passed the Nuclear Waste Policy Act, establishing a site-selection process for a geologic repository.

1986

DOE issued environmental assessments for five potential sites; recommended three of the five sites for characterization. President Reagan approved the recommendations.

1987

Congress amended the Nuclear Waste Policy Act to direct DOE to characterize only Yucca Mountain as a potential repository.

1995

DOE issued a notice of intent to prepare the Yucca Mountain Repository environmental impact statement.

1999

DOE issued draft Yucca Mountain Repository environmental impact statement.

2001

DOE issued supplement to the draft environmental impact statement. DOE issued documents relevant to site suitability and a potential site recommendation.

2002

DOE issued final Yucca Mountain Repository environmental impact statement. DOE made site suitability determination and recommendation.

2008

DOE submitted a license application to the Nuclear Regulatory Commission.

2010

Yucca Mountain Repository funding ceased.

Program ceased before DOE received construction authorization.

Program put on pause.

Program ceased before repository emplacement operations began.

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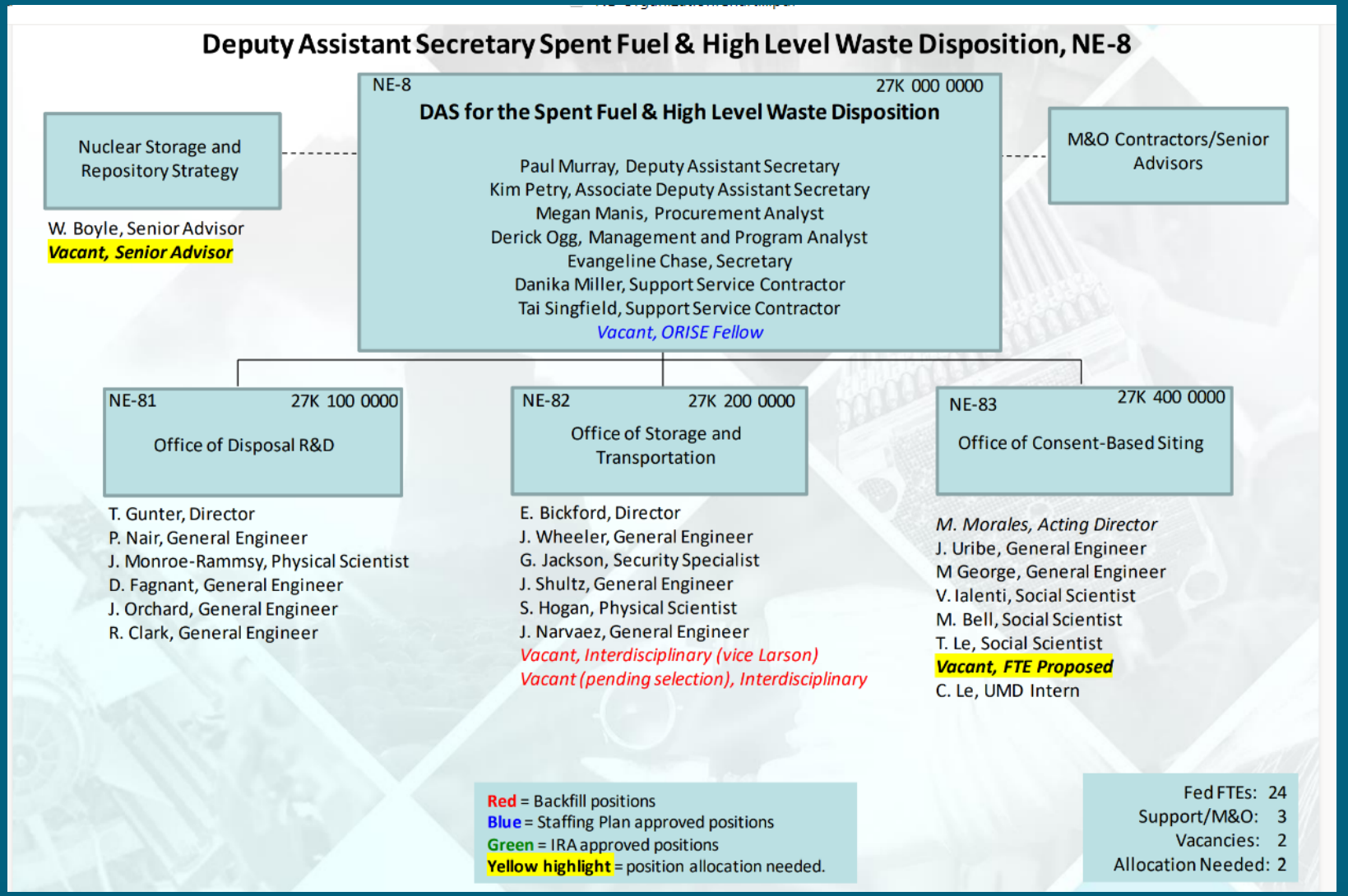
Stakeholders

1. Commercial Spent Nuclear Fuel ~ 140,000 tons
2. DOE Environmental Management High Level Waste from:
   - Savannah River HLW Vitrified Canisters
   - Hanford Site HLW Vitrified Canisters
   - West Valley Demonstration Project HLW Vitrified Canisters
   - Idaho ~ 6000 cubic yards, Calcine Waste
3. Naval Reactors Spent Nuclear Fuel
4. DOE Spent Nuclear Fuel
   - Road ready demonstration at INL
5. Advanced Reactors Spent Nuclear

NE-8 Organization

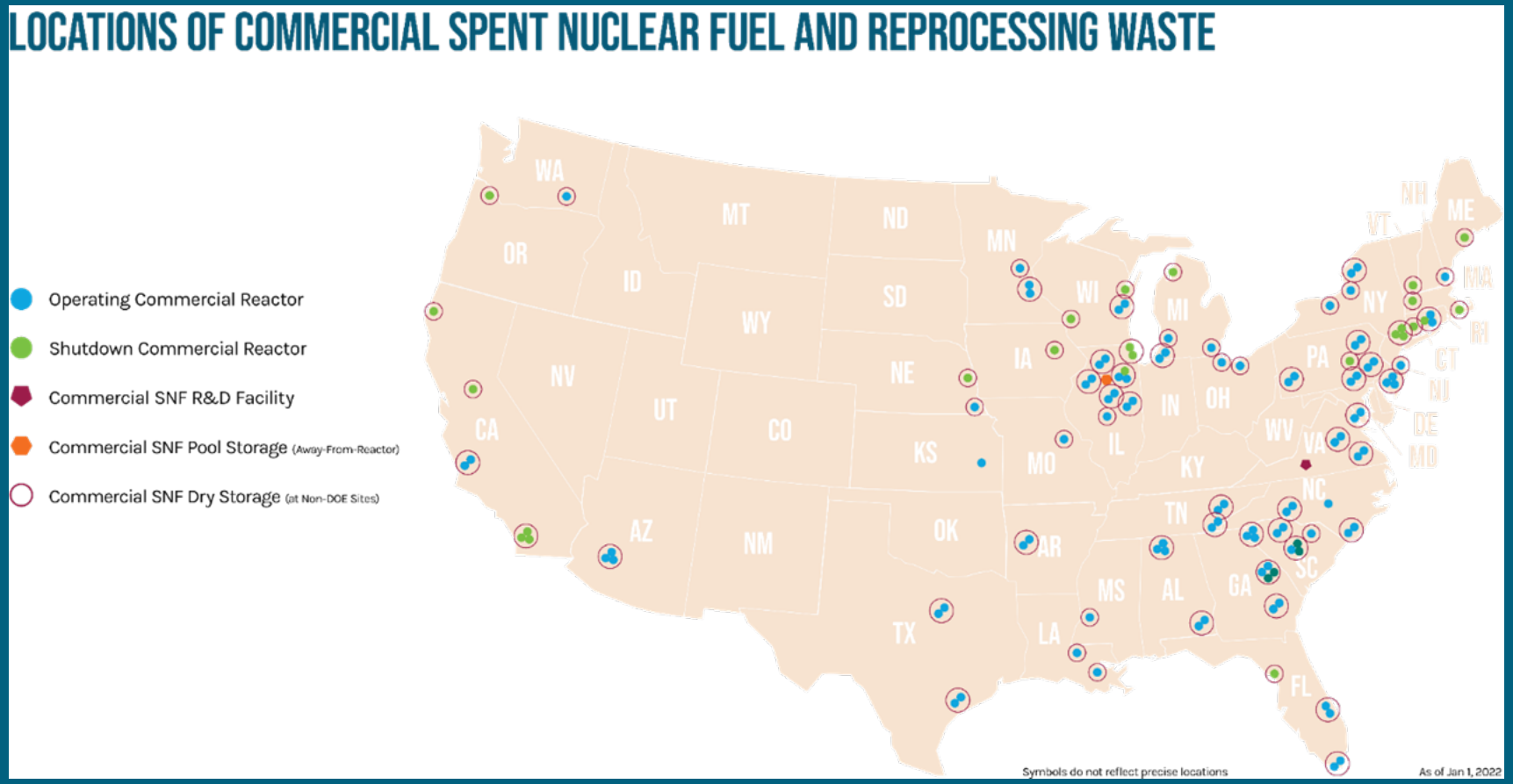


Taxpayer Liability for Spent Nuclear Fuel*

Fiscal Year Ending	DOE's Estimate of Total Liability	Amount Paid from Taxpayer Funded Judgment Fund		DOE's Estimate of Remaining Liability (Total less Amount Paid)
		Cumulative	Annual	
9/30/2023	$ 44.7 Billion	$ 10.6 Billion	$ 500 Million	$ 34.1 Billion
9/30/2022	$ 41.1 Billion	$ 10.1 Billion	$ 1.1 Billion	$ 31.0 Billion
9/30/2021	$ 39.9 Billion	$ 9.0 Billion	$ 400 Million	$ 30.9 Billion
9/30/2020	$ 39.2 Billion	$ 8.6 Billion	$ 600 Million	$ 30.6 Billion
9/30/2019	$ 36.5 Billion	$ 8.0 Billion	$ 600 Million	$ 28.5 Billion
9/30/2018	$ 35.5 Billion	$ 7.4 Billion	$ 500 Million	$ 28.1 Billion
9/30/2017	$ 34.1 Billion	$ 6.9 Billion	$ 800 Million	$ 27.2 Billion
9/30/2016	$ 30.8 Billion	$ 6.1 Billion	$ 800 Million	$ 24.7 Billion
9/30/2015	$ 29.0 Billion	$ 5.3 Billion	$ 800 Million	$ 23.7 Billion
9/30/2014	$ 27.1 Billion	$ 4.5 Billion	$ 800 Million	$ 22.6 Billion

* Source: DOE Nuclear Waste Fund Annual Financial Statement Audit Reports. Over time, these estimates have been based on varying assumptions including when DOE would begin removing commercial spent nuclear fuel from reactor sites. During the ten-year window covered by the table, the date has been pushed out ~ 17 years. In FY 2023, DOE utilized a range approach for “subsequent license renewals” – the numbers in the table above represent the low end of the range.

U.S. Spent Nuclear Fuel In Context



1958
United States began using commercial nuclear power

2023
93 operating commercial reactors at 53 nuclear power plant sites in 28 states

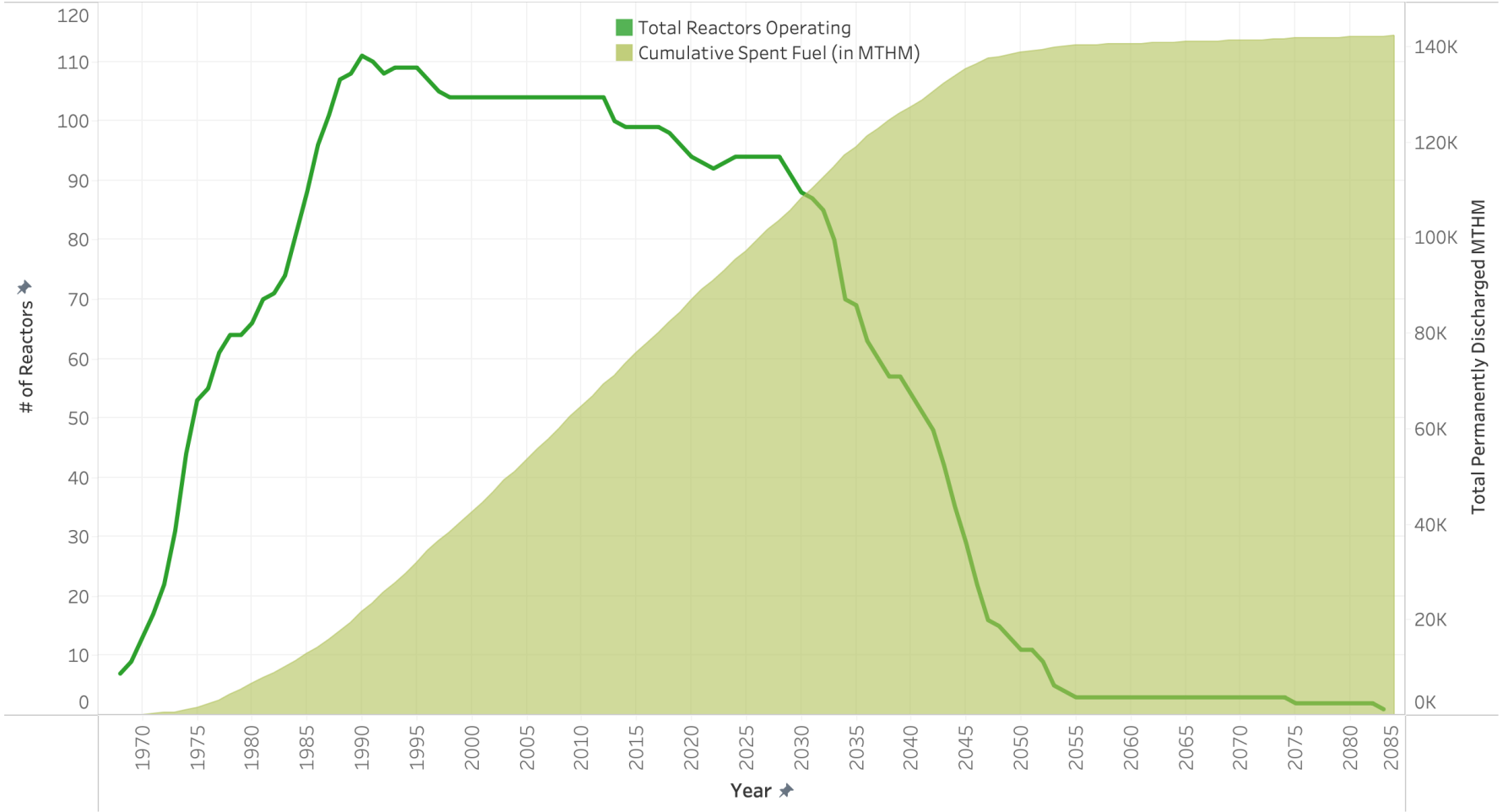
- 20 nuclear power plants have shut down
- 90,000+ metric tons of spent nuclear fuel

End of Current Fleet
United States estimated to have ~140,000 metric tons of spent nuclear fuel

Who is responsible for the management of SNF?

Total Reactors Operating vs Cumulative Spent Fuel

Commercial Reactors in the United States; Including Vogtle 3 and 4; 60-Year operating life is assumed for currently operating reactors except six reactors that obtained license extension to 80 years



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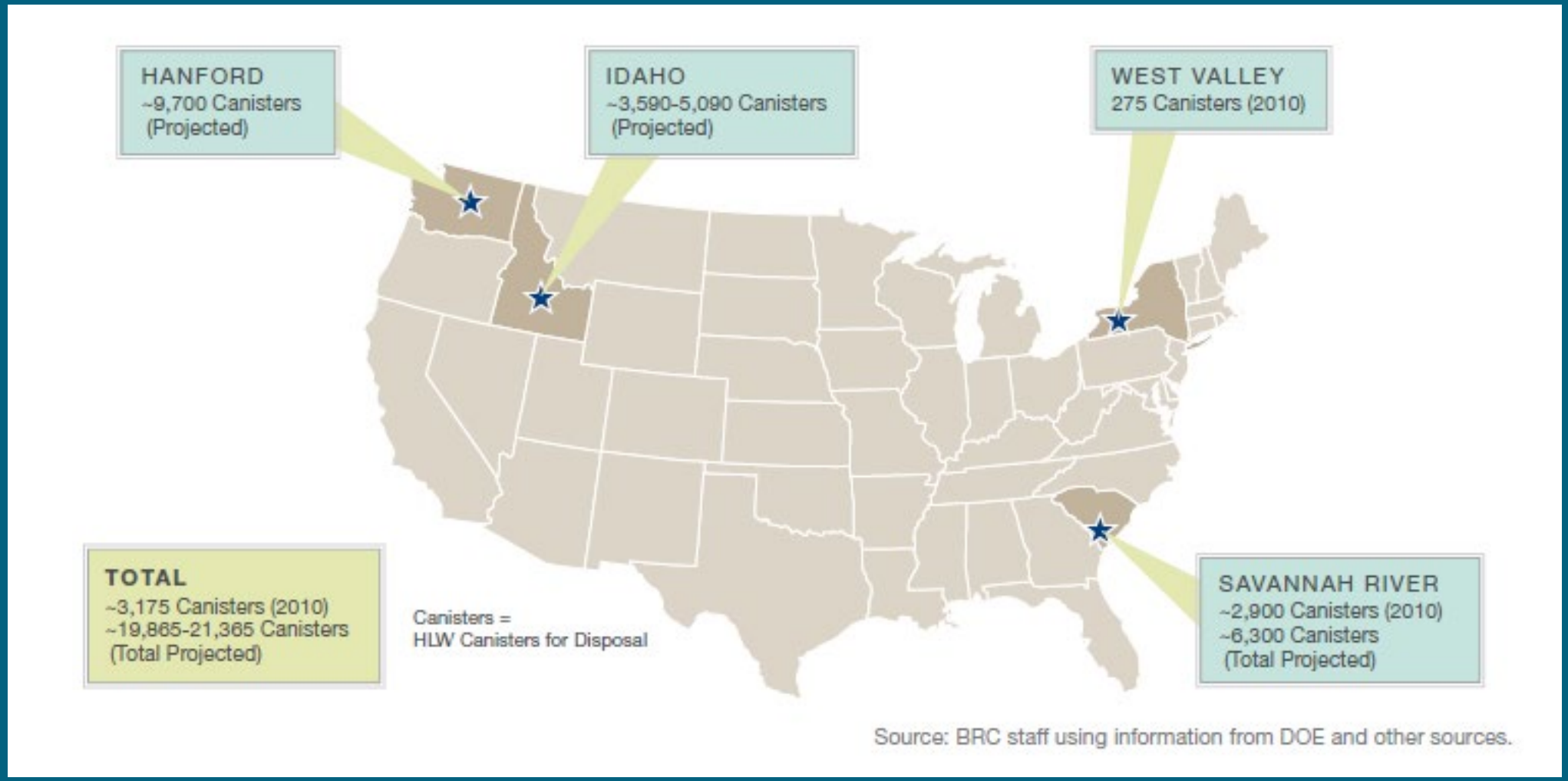
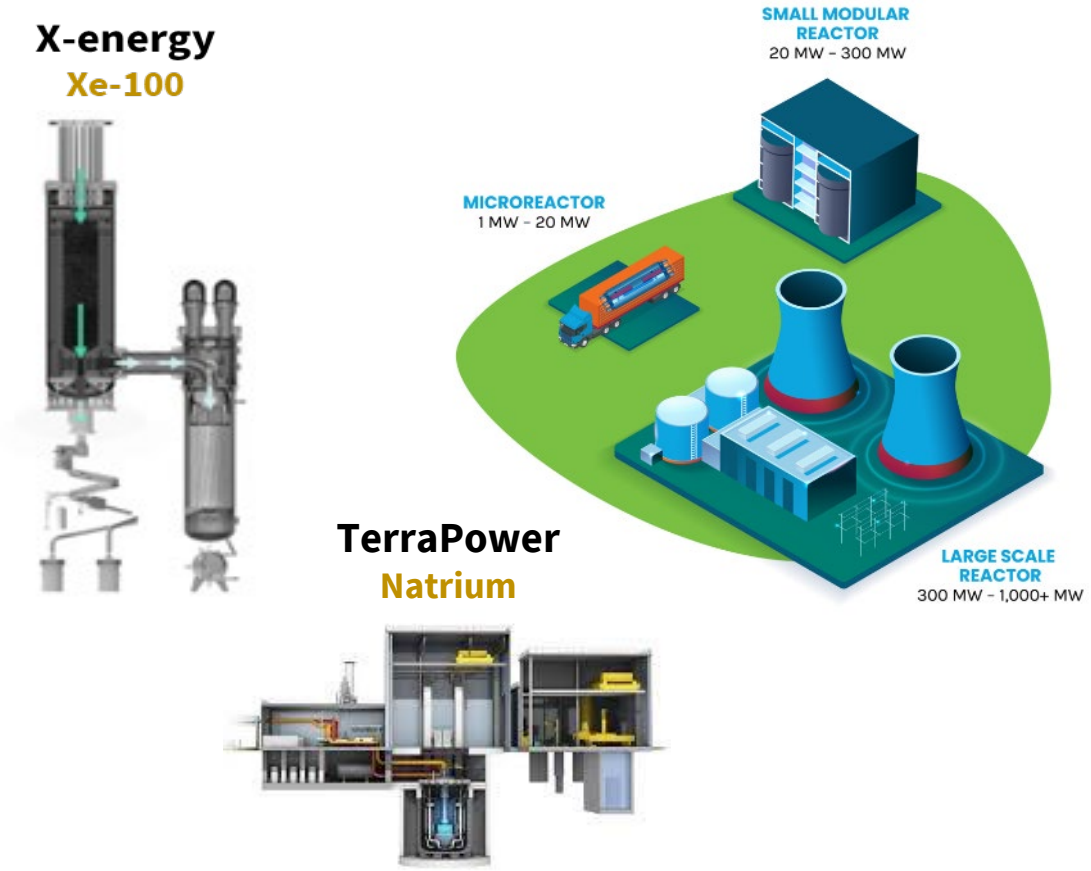
DOE SNF and HLW

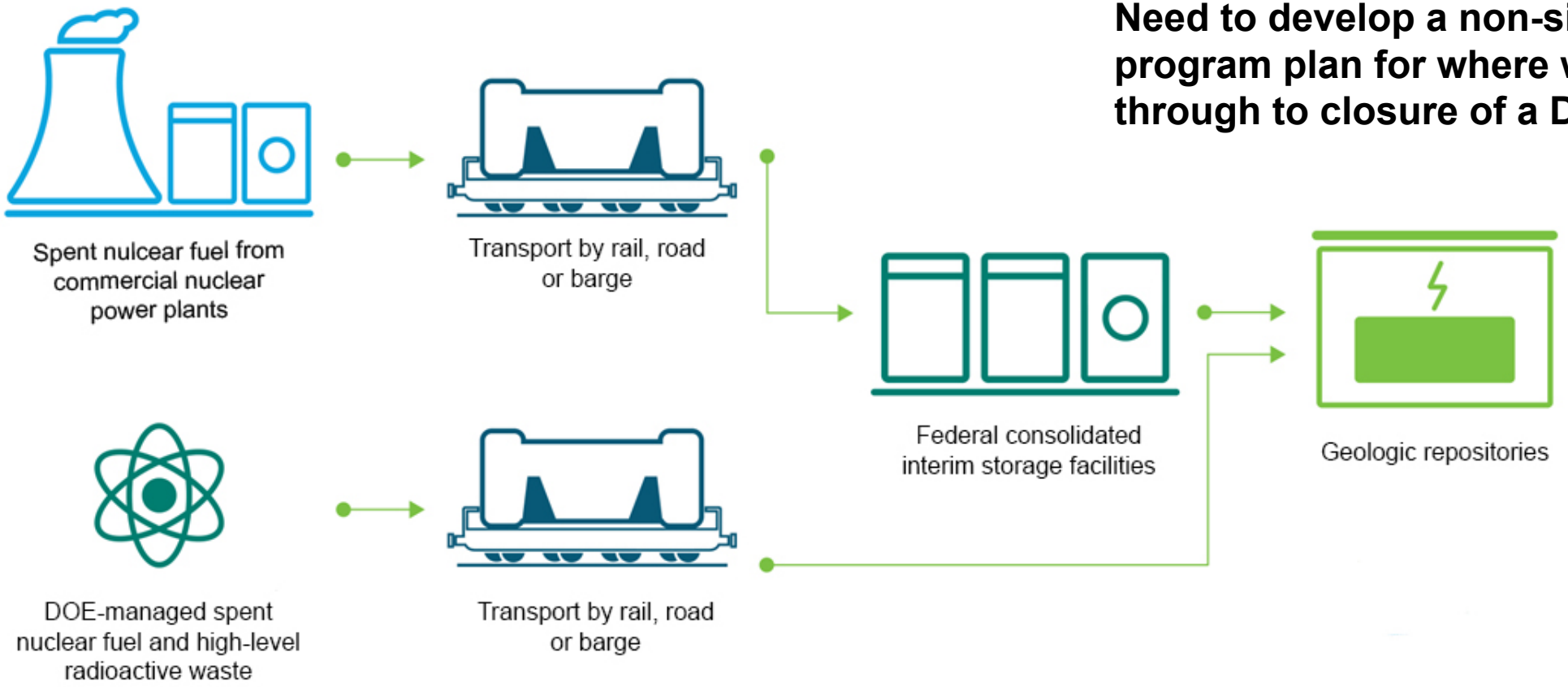


Considering Waste Management for Advanced Reactors

- NRC License Approach
- DOE's integrated project team on back-end management of advanced reactors
- Technical assessment of storage, transportation, and disposal
- Preliminary cost assessments/comparison
- National Academy of Sciences study funded by DOE



Integrated Waste Management System



Need to develop a non-site specific program plan for where we are today through to closure of a DGR?

Waste Stakeholders Engagement

1. Work with DOE EM and NR on the non-site specific program plan to consider all options for management of all the SNF and HLW.

2. Work with DOE EM and NR on updating the source term/ waste acceptance criteria for a future DGR.
    1. Can we accept and dispose of DPC's
    2. How does EM stabilize future wastes.

International Center for Research on SNF and HLW

1. Consolidate R&D programs for SNF and HLW storage into one center based on the CASL hub and spoke model. R&D will focus on next 5 to 7 years.

2. The lead laboratory will host the HBU Demo cask.

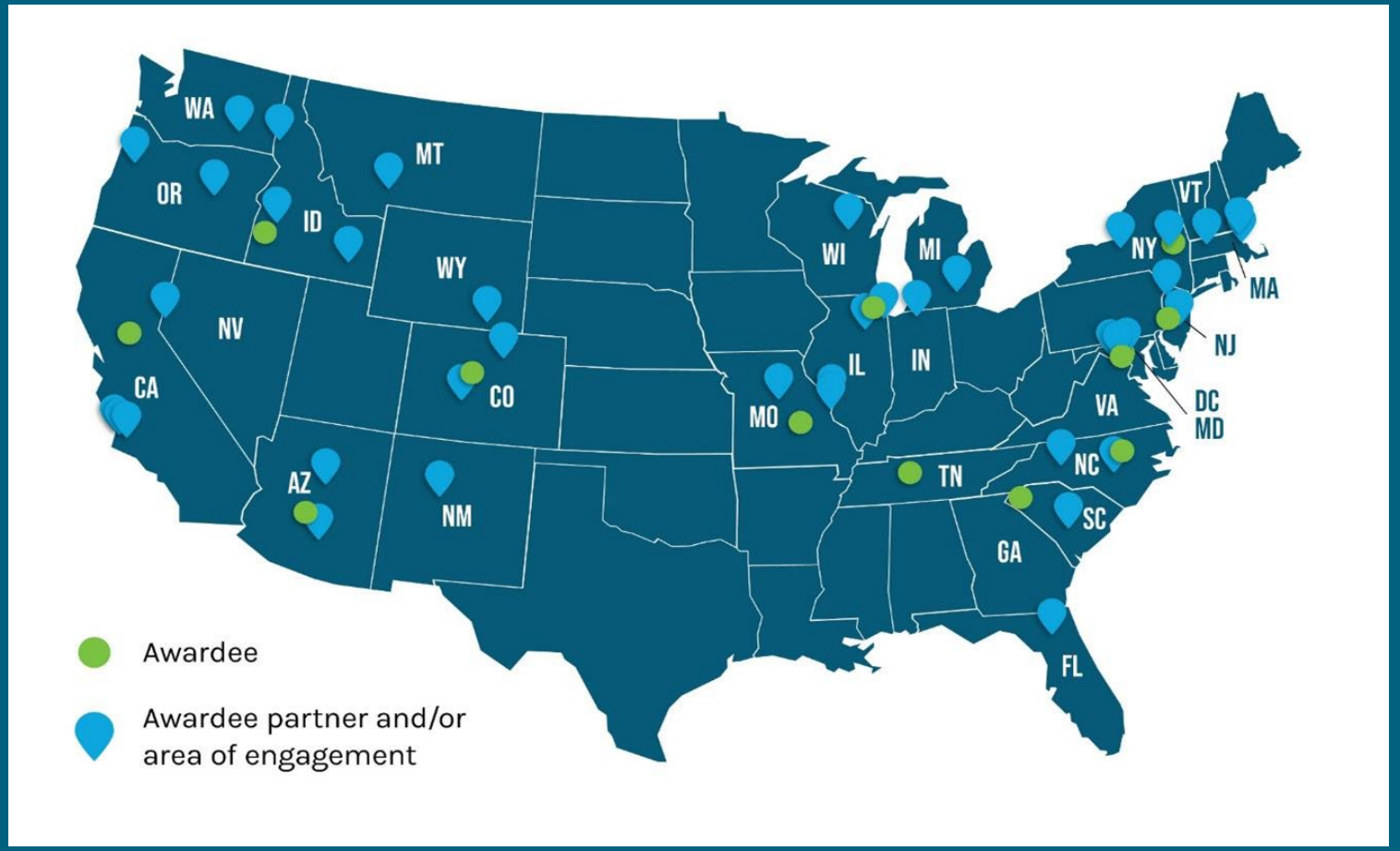
3. Work with DOE EM on collaborative R&D programs.
   a) We are both funding similar R&D programs.

4. Support the INL Road Ready demo and the L Basin de-inventory at SRS.

5. Many countries have SNF and HLW R&D programs similar to DOE.
   a) We will explore collaboration to share results.

Consent-based Siting Consortia

- On June 9, 2023, DOE selected geographically and institutionally diverse awardees to serve as information, engagement, and resource hubs, referred to as consent-based siting consortia. The consortia will foster community discussion and capture feedback on interim storage of spent nuclear fuel.
- Locations identified represent principal investigators, partners, or communities that will participate in the awards. DOE is not looking for volunteer communities to host interim storage facilities in this stage of the consent-based siting process. As such, the locations identified do not represent locations being considered for a consolidated interim storage facility for commercial spent nuclear fuel.



CONSENT-BASED SITING CONSORTIA PROGRESS

Consent-based siting consortia support DOE's efforts to facilitate inclusive community engagement and elicit public feedback on consent-based siting, management of spent nuclear fuel, and federal consolidated interim storage. The 12 awardees are comprised of various organizations to help reach communities across the country and remove barriers to participate in DOE's consent-based siting process. **Awardees have made significant progress in carrying out community engagement activities and providing direct grants to communities wanting to learn more.**

30 Consortia Public/Media Engagements Held

21 New Team Members Brought into the Consortia Effort

3 Community Sub-Grant Programs Issued

20 Information Resource Projects

9 Government Engagements Held (Tribal, State, Local, Federal)

Progress: DOE's Consent-Based Siting Process General Timeline

Progress: Consent-Based Siting Consortia Timeline

Updates reflect activities from September 2023 up to mid-March 2024.

To learn more about these metrics, please visit energy.gov/ne/consent-based-siting-consortia or send an email to consentbasedsiting@hq.doe.gov

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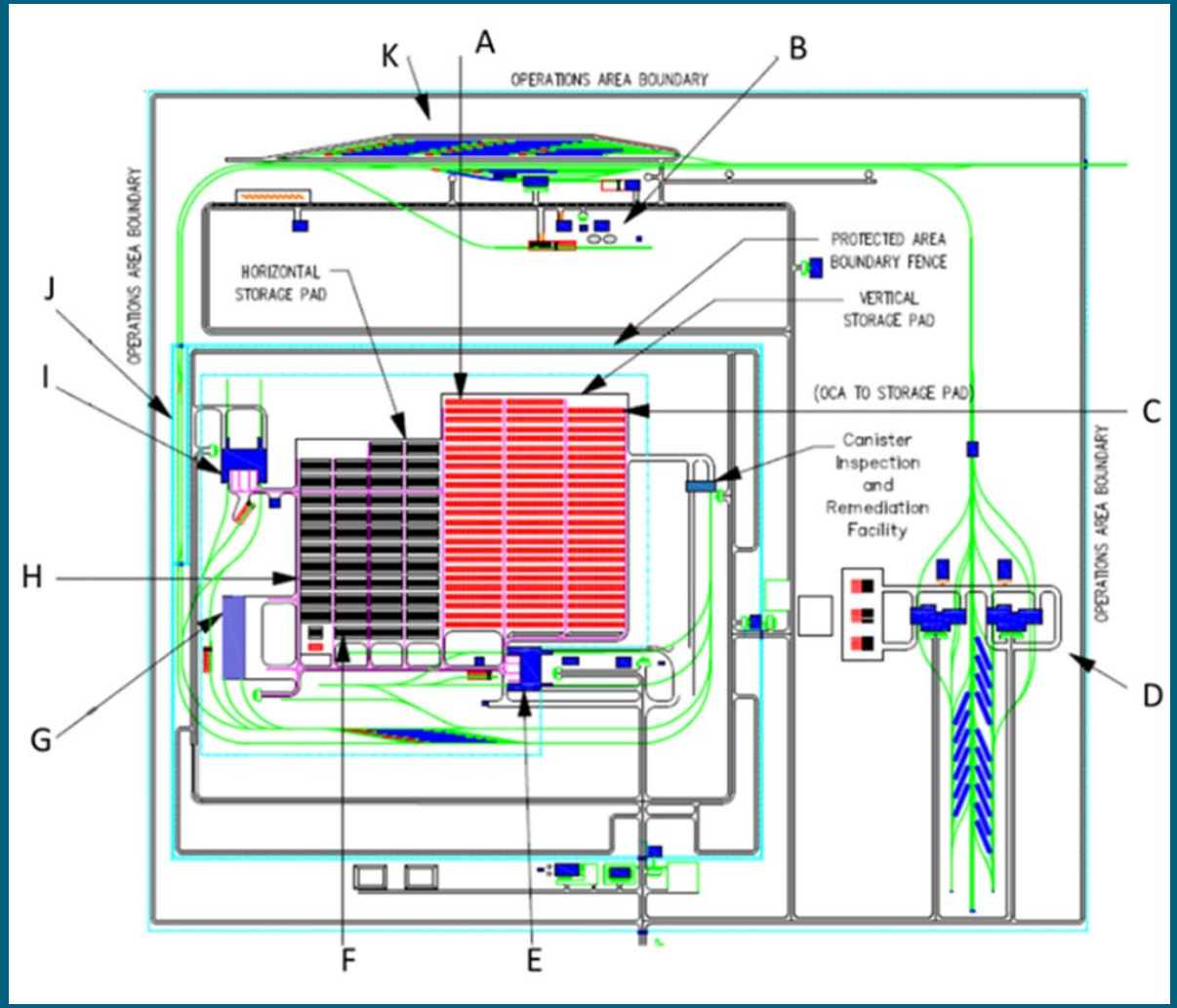
Consolidate Federal Interim Storage

- Design proceeding on schedule.
- Review by Dep Secretary on May 3rd for approval of the CD0 design concept.
- When approved we can start CD1.
- In FY 2025 will use program funds to maintain momentum.
- In FY 2026 will apply for line item funding.
- Liabilities chart assumes start of operations in 2038. Any later will increase the nations liabilities.
- Working with DOE EM to ensure Road Ready Demo at INL and L Basin de-inventory could ship to facility,



High Burn-up Demonstration Cask

- Supporting the safe long term dry storage of high burn-up fuel at utility sites
- All SNF is now HBU
- Important to license renewal applications for over 60 of the current commercial fleet.
- Upcoming NRC “Toll Gates” require cask to be opened in 2029 to supply data in 2038
- Need to move the cask from operating reactor site to new home

2024

Consent-Based Siting/Public Outreach

2025 Conduct a demonstration of the Atlas rail car

Design of Consolidated Interim Storage Facility

2026 Establish the International Center of Excellence for the Research of Spent Nuclear Fuel

Transportation of Spent Nuclear Fuel

2027 Move high burnup cask

2027 – 2036 Move spent nuclear fuel from shutdown reactor sites?

2034 Build out transportation infrastructure for spent nuclear fuel

2038

Repository Program

- Consider all options for the program in line with the Nuclear Waste Policy Act.
- Continue to support international R&D related to generic repository model.
- Evaluating sending DOE Engineers and managers to work on international programs.
- Build capability in US industry to support the start of a future program.
- Rebrand the Total System Performance Models for a future repository. Link back to re-evaluate the WAC.
- Exploring how to collaborate with EM on lessons learned from WIPP.

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Questions

DOE-NE R&D Efforts on Nuclear Fuel Recycling

Nuclear Energy Advisory Committee Virtual Meeting

April 30, 2024

Stephen Kung
Senior Advisor, Office of Nuclear Fuel Cycle (NE-4)
Acting Office Director, Materials and Chemical Technologies (NE-43)
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Content

Material Recovery and Waste Forms Development (MRWFD)

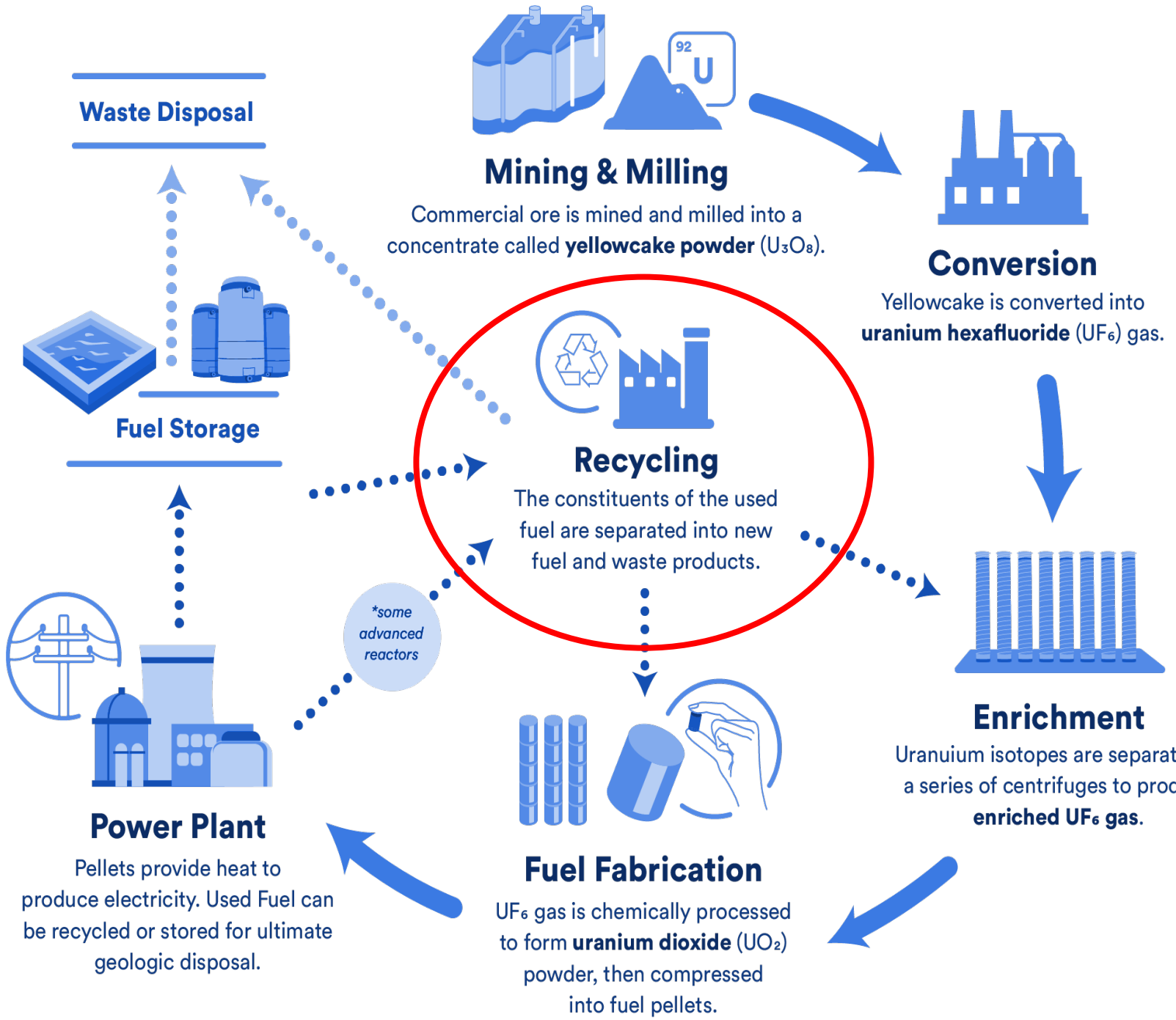
Technology Focus Areas

- Aqueous and Vapor Phase Separations
- Pyroprocessing / Molten Salt Separations
- Off-gas Capture and Immobilization
- Adv. Waste Form Development

Domestic Nuclear Materials Safeguards and Security Program

How the Nuclear Fuel Cycle Works

Recycling could provide economic and waste management benefits, while spurring domestic adoption of advanced reactor technologies – making the U.S. more competitive in global market and advancing U.S. energy security and carbon reduction goals.



Materials Recovery & Waste Form Development (MRWFD)

Mission – Develop advanced fuel recycle technologies to improve resource utilization, reduce repository burden, limit proliferation risk and improve economics.

Implementation Strategies:

- Use recycling technologies to produce HALEU materials for advanced reactor fuel-fabrication R&D needs;
- Address nuclear materials separation and recovery challenges for various advanced reactor designs;
- Develop efficient and economical technologies for commercially viable future industrial deployment;
- Maintain and expand the capabilities and knowledge in nuclear chemistry for a broad range of nuclear applications.

MRWFD Fundings and Major R&R Technologies

	FY23	FY24	FY25
Funding	$45M	$55M	$38.5M

MRWFD Technology Focus Areas

- Aqueous and Vapor Phase Separations
- Pyroprocessing / Molten Salt Separations
- Off-gas Capture and Immobilization
- Adv. Waste Form Development

Domestic Nuclear Materials Safeguards and Security Program

Advanced Aqueous Phase Separations

- Direct Extraction of Voloxidized Powder into Organic Extractant
- Alkaline side Separation Schemes
- Innovative Control of Reagent and Solution Chemistry
  - New ligands for U single cycle extraction
  - New reagents for Tc sequestration and Np redox control
- Real-time Inventory Determination and Characterization
- Automated Processes Using Robotics and Artificial Intelligence

Vapor Phase Separations

- Debundling of Fuel Assembly
- Advanced Voloxidation for Off-gas (reducing cost by 7%)
- Fluoride Volatility Recovery of Uranium with Safeguards
- Low Temp Chemical Decladding of LWR and of Zr and Al Claddings
- Zr Recovery and Reuse - including 90Zr enrichment
- Mechanochemical Methods to Covert Oxides to Halides

Pyroprocessing / Molten Salt Separations

Activity	Oxide Fuel	Metal Fuel	MSR Fuel
• U/TRU co-deposition at solid cathode (hot demonstration)	✓	✓	✓
• Separation of molten U/TRU product and molten salt in bottom-pour furnace	✓	✓	✓
• Upgrade engineering-scale electrorefining equipment	✓	✓	
• Evaluate common salt (LiCl) for oxide reduction and electrorefining	✓		
• Simplified separation of Group I and II fission products from molten salts	✓	✓	✓
• Single step conversion of UF_4 → $UCl_{3/4}$			✓
• Direct halogenation of actinides (metal and oxide)	✓	✓	✓
• Molten Salt Reactor Fuel Cycle Chemistry Workshop (identify R&D needs)			✓
• Develop pCl^- probe to measure activity of free (uncomplexed) Cl^-			✓
• Sense and characterize formation of insoluble oxide particles	✓	✓	✓

Advanced Waste Form Development and Off-gas Capture

- Developing advanced waste form and off-gas technologies that improve current fuel cycle performance and enable a sustainable fuel cycle with minimal processing, minimal waste generation and a limited proliferation risk
  - Specifically developing
    - Processes for the capture of iodine, tritium, krypton and carbon that can be implemented across used fuel treatment processes.
    - Durable advanced waste forms for waste streams generated during fuel production and reprocessing operations to optimize formulations and performance.
    - Interfaces with the repository development teams, the accountancy teams along with the NRC.

Domestic Nuclear Materials Safeguards and Security Program

Milestone 2020

- Safeguards and Security by Design (SSBD) demonstration

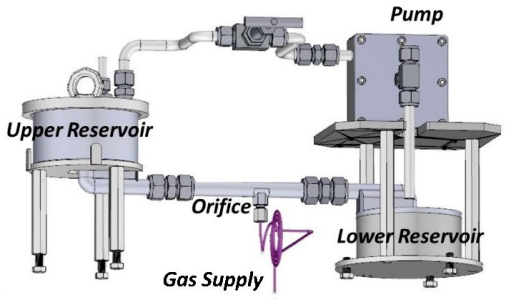
Domestic Safeguards Performance Models

- Developed models for recycling flowsheets (PUREX, Single-Step Aqueous, CoDCon, ZIRCEX).

Technology Development

- Microcalorimeter for analytical lab and rapid/high precision analysis throughout fuel cycle R&D.
- Sensors for molten salt system measurements (concentrations, density, height)
- Advanced electronics for Non-Destructive Assay (NDA)

Triple bubbler for salt height and density measurements



Molten Salt Sample Extractor

- Incorporate domestic safeguards into early R&D stage of the fuel cycle process
- Developing instruments for on- & off-line process control for Material Control and Accountancy (MC&A) purposes
  - Developing integrated system to incorporate accountancy at the initial de-cladding stage
  - Rapid assay for real or near real time accountancy
  - Developing automated holdup measurement tools

Funding:

FY23: $5.5M
FY24: $5.5M
FY25: $5.3M

Thank you

Questions?

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Break

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Subcommittee Activities Update

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Infrastructure

Stu Bressler

NEAC Subcommittee Updates and Discussion

Overview of the Scope and Progress of the Infrastructure Subcommittee

Committee **had the mandate of understanding the infrastructure investment** needed to support the expansion of **>**200 GW of capacity by 2050. **The scope of this can be broad**

- Workforce development
- Continuing innovation
- Demonstration of advanced concepts
- Large-scale commercialization

The committee **also met with numerous DOE presenters** to understand current challenges in the Infrastructure space:

- Alice Caponiti, Deputy Assistant Secretary (NE-5, Reactors)
- Patrick Edgerton, Director, Office of Budget and Planning, NE
- Julie Kozeracki and Christopher Vlahoplus, DOE Loan Programs Office

As a result, we have prepared a set of recommendations to maintain scope in a way that is useful for NE

Summary of Recommendations

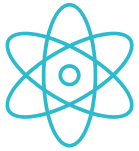
1. Mission Need
2. Focused Deployment Strategy
3. Demo projects (short-term)
4. Materials, Construction, Workforce (medium & long-term)
5. Timescale strategies (medium & long-term)
6. HALEU prioritization
7. Reprocessing and recycling
8. User Facility Models
9. Capability Metrics
10. Advanced Reactors Input
11. Commercial deployment R&D

Detailed Recommendations: General (1-2)

1 Mission Need:

NE should **develop an effective narrative around the need for and benefits of nuclear energy given the worldwide efforts to decarbonize**.

The narrative should acknowledge the needs associated with combating climate change in the near term but also sustain those efforts beyond 2050 with continuous improvements



2 Focused Deployment Strategy:

NE **develop an infrastructure strategy that is focused on achieving established priorities**, the most important of which is accelerating commercial deployment of existing reactor technology in the near term and advanced reactor technology in the long term.

The strategy should include a clear indication on the goals, timelines, and expected benefits.

Detailed Recommendations: Short, Medium and Long-Term (3-5)

3 Demo projects (short-term):

Highest priority focus in the near term is **moving forward expeditiously on getting more nuclear capability into commercial operation through demo projects utilizing** existing technology. Longer term these issues tie to integration into industrial use cases, which may require new facilities for systems testing.

4 Materials, Construction, Workforce (medium & long-term)

The recent report from National Academy of Engineering and the DOE Liftoff report recommended a **focus on materials development, construction technology R&D and workforce development**.

Infrastructure is needed to support materials and construction R&D and certainly university training infrastructure to build workforce could be an area of emphasis.

5 Timescale strategies (medium & long-term)

NE should focus on strategies (including project management tools) to **shorten the timescales for nuclear projects** and a new science-based paradigm for material qualification and licensing process.

Detailed Recommendations: Supply Chain for Advanced Reactors (6-7)

6 HALEU Prioritization:

NE should prioritize implementation of the infrastructure necessary for **commercialization of High Assay Low Enrichment Uranium (HALEU)** advanced reactors

There needs to be a longer term focus, to focus on the commercialization of nuclear technologies, on solving this problem, and **stimulating production in the absence of specific orders with a recognition** that there will be demand for the product once larger scale production is a reality

7 Reprocessing and Recycling:

Assuming nuclear energy production transitions to HALEU fuel, reprocessing and recycling **will need to be seriously considered**.

Reprocessing HALEU fuel should follow along with addressing the **large-scale supply issue** to ensure we address uranium utilization and supply reliability

Incorporating recycling into advanced reactor deployment **would take 15-20 years**; thus, the foundations must be established today

Detailed Recommendations: Physical and Intellectual Infrastructure (8-9)

User Facility Models:

8

Establish tight coordination between the **university infrastructure and national laboratory physical infrastructure programs** with adequate access models (user facility models) to an integrated set of capabilities.

It appears this is successfully being done by Nuclear Science User Facility, which can be expanded as the capabilities at the universities grow with additional investments

Capability Metrics:

9

Develop a metric to **measure how well the different pieces of the existing infrastructure is being used** to support the national priorities and evaluate if there are some savings there by repurposing or shutting down facilities with little or no interest to free up funding for other priorities.

Determination of the **most important capabilities that MUST be preserved** to support the nuclear energy strategy with quantitative analysis of benefits would be very informative

Detailed Recommendations: Advanced Reactors and R&D (10-11)

10 Advanced Reactors Input:

NE should obtain clearer input from industry through a workshop between NE and the Working Groups, or some other form of face-to-face interaction that results in **meaningful prioritization of the Working Group feedback**

NE should facilitate a mechanism for receiving that **clarified feedback given the Subcommittee's** impression that additional interaction with and information from the industry would be beneficial in accomplishing other of our recommendations

11 Commercial deployment R&D:

NE should establish R&D priorities specifically with respect to infrastructure with an emphasis on R&D that **accelerates the bridge to commercial deployment**. There should also be a definitive tie between the R&D programs to the ARDP and other demo programs

The area where NE has more direct control over investment strategies and priorities is on the R&D infrastructure

Potential Follow Up Topics for the Subcommittee

Subcommittee could help to continue to develop **priorities for funding**

- This may require additional members with expertise outside the current NEAC members

Development of **comprehensive R&D infrastructure** – the subcommittee would benefit from a presentation if there is a strategic approach to this topic

Further exploration on the **models needed for large-scale commercialization** of advanced reactors:

- Can the existing mechanisms work or is a new paradigm necessary?
- Who owns them? What can NE do to make them actionable?

Work alongside the **workforce subcommittee** to identify the existing infrastructure that can support needs and identify gaps for new investments

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Consent-Based Siting

Dr. J'Tia Hart

NEAC Subcommittee Updates and Discussion

Overview of the Scope and Progress of the Consent-based siting Subcommittee

Committee had the goal of understanding the current status of the **Nuclear Waste Management** within NE

The group met with a few officials on the topic, including:

- Former Senator Jeff Bingham, who provided context on the Nuclear Waste Administration Act
- Lisa Frizzel, Nuclear Waste Management

As an outcome of these conversations, they want to applaud the efforts of the Office of Nuclear Energy regarding nuclear waste management, specifically:

- The 2021 request for information
- The 2023 funding opportunity announcement support by Congress in the Consolidated Appropriations Act of 2023

Summary of Recommendations

Acknowledge that the Consent—Based Siting (CBS) process requires iteration:

DOE should move at the “speed of trust” solely determined by stakeholders and allocate sufficient time

Allocate Funding for Future Support:

DOE should allocate resources for continued continuity and stakeholder engagement as well as advocate for collaboration between consortia partners with expanded timelines, scope, funding, etc.

Advocate for Expanded Stakeholder Engagement:

DOE should advocate for expanded input with civil society organizations that represent marginalized communities. They should facilitate available and access to expertise

Advance Publication Timeline for Integrated Waste Management Strategy:

The DOE should expedite publication of an integrated waste management strategy with common community awareness as a foundation

Follow Up on Topics and Next Steps

- **The subcommittee is currently considering and will issue a subsequent report regarding:**
  1. The creation of an independent organization to manage CBS
  2. Access to waste funding to support CBS
  3. Site governance options such as partnerships with local, state, and regional organizations
  4. Formation of an advisory panel comprised of social, local, and technical stakeholders such as those from previous successful projects
  5. Relevance of previous recommendations from studies and commissions on this topic

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Workforce of the Future

Dr. Sonja Schmid

NEAC Subcommittee Updates and Discussion

Overview of the Scope and Progress of the Workforce Subcommittee

The Workforce Committee **had the mandate of understanding (a) the nature, size, and skillset of the nuclear workforce needed in the future** to support a 2050 decarbonization goal, as well as **(b) the gaps and problems** associated with achieving this goal.

During multiple meetings over the last year, the committee **heard from numerous presenters** on challenges surrounding the future nuclear workforce, including:

Ken Czerwinski, UNLV, PI of SUSTAIN
Lori Brady, NEI
Alice Caponiti, Deputy Assistant Secretary and her team
Melinda Higgins, Director of STEM programs

As an outcome of our discussions, we have put together **three preliminary recommendations** based on a series of topics we discussed. These are intended as an update on work in progress; the Workforce Committee plans to continue its deliberations.

Preliminary Recommendations

1 Broaden funding targets:

Create new programs (and strengthen existing 4y-college and graduate programs) to improve diversity and the inclusion of e.g., community colleges, trade school programs, non-traditional students and career-changers. Support certificate programs, mentorship and Union apprenticeship programs by building and expanding networks with faculty, community and tribal colleges, and by actively encouraging curricular innovation.

2 Diversify the content:

Expand the content of training beyond the technical by committing a percentage of funding to social sciences and humanities training, and to a comprehensive perspective on nuclear energy. An open, critical, and nuanced discussion of the context of nuclear energy (environment, justice, labor etc.) is vital to support the growth of a workforce that is not only technically competent but also able to navigate difficult debates over a troubled history.

3 Share the results:

The UNLV SUSTAIN study, and industry gap analyses, should be advertised together with the availability of various grants and fellowships. Improve and revitalize community engagement through public-facing infrastructure (e.g. universities, national labs, and commercial entities) to establish nuclear facilities as trusted members of the community.

Follow on topics and next steps for the Workforce Subcommittee

Work alongside the **infrastructure subcommittee** to identify what existing and desirable infrastructure would best support the future nuclear workforce

Coordinate with the **international subcommittee** to assess how other countries succeed at training a nuclear workforce and what aspects are worth emulating

Interface with other units in DOE and elsewhere on training international leaders and decision-makers

Develop specific suggestions on how to expand the language and definition of appropriations to help broaden future workforce funding targets

Learn more about topics such as:

- The role of tribal colleges in contributing to the future workforce;
- Unconventional workforce challenges (temporary, transient, surge workforce), potentially through examples from other industries;
- Successful models to train workers to engage critically with their own industry, and how nuclear workforce curricula could emulate these.

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International Engagement

The Honorable William D. Magwood, IV
NEAC Subcommittee Updates and Discussion

Overview of the Scope and Progress of the International Engagement Subcommittee

Launched its work with the **goal of understanding the driving objectives of the US government's international nuclear energy activities.**

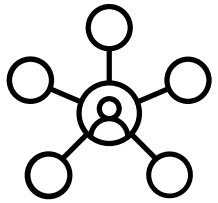
Subcommittee **met with a range of senior officials**, including:

- Undersecretary of State for Arms Control and International Security
- DOE Assistant Secretary for International Affairs
- Deputy Administer for Defense Nuclear Nonproliferation at the National Nuclear Security
- Assistant Secretary of Commerce for Industry and Analysis

Through these conversations, found:

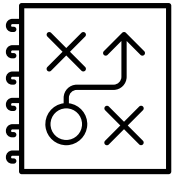
- Support for the domestic benefits of a strong nuclear industry and of U.S. climate goals
- Common understanding across the many agencies
- Appreciation for the bipartisan nature of these policies

Summary of initial observations



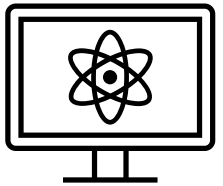
Concerns about in the U.S. government's current framework:

- Various agencies largely operate in their own lanes
- No clear organizing mechanism or strategic focus
- There are gaps in the policy framework



Example: U.S. is overmatched by the competition overseas:

- Agencies haven't developed a strategy to address this fact
- Heroic effort in one case have dealt with the financing issue in one case, but this was complex and time-consuming



Lack of long-term view in developing relationships with potential partners:

- Example: Whereas Russia and China engage with Africa countries early and establish significant training programs, the US typically engages quite late in the progress toward building plants

Primary Observations and Suggestions

1. **Strategic vision:** The USG requires a more comprehensive strategic framework in which NE and other elements can work and cooperate. The subcommittee suggests a policy-level interagency discussion

2. **Long-term investment in overseas relationships:** The US should provide enhanced support to identify and develop potential customer nations

3. **Financing of Overseas Projects:** Financing is critical to U.S. nuclear competitiveness abroad. Ex-IM, U.S. IDFC and USTDA must have the capacity and latitude to compete and multinational institutions should be updated

4. **Export policies:** As the global market for nuclear exports rapidly expands, framework agreements will be needed with more partner countries

Focus Areas for the Subcommittee

5. Ensure a U**.S. solution for fuel supply**, particularly LEU and HALEU. This is a threshold issue for both the near term and the long term and is essential in building the confidence of potential partners. Further work is needed; suggest cooperation with Infrastructure subcommittee.

6. The Subcommittee plans to make **Financing of Overseas Projects** a key focus area for the coming months and will investigate the views of the involved organizations, both in the US Government and in international financial institutions. The Subcommittee will also maintain awareness of relevant legislation pending in Congress

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Discussion of Next Steps & New Issues

The Honorable William D. Magwood, IV, Chair

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Public Comment

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Closing Remarks

Dr. Kathryn Huff, Assistant Secretary for Nuclear Energy
The Honorable William D. Magwood, IV, Chair

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Meeting Adjourned