High-Assay Low Enriched Uranium (HALEU) Informational Update

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• FOA Appendix A
• HALEU Supply Chain Considerations
• April 2020 GAIN/NEI/EPRI Workshop
• Status of NE HALEU Activities
• Issues: Integration, Stakeholder Roles
• DOE Focus & Conclusions
Establishing a reliable HALEU supply chain will require effective execution of production, transportation, and fuel fabrication

- **Production**: The only viable long-term approach for production of HALEU in commercial quantities is the establishment of additional enrichment capabilities.

- **Transportation**: Applicants should consider a strategy for transportation that fits their needs profile.

- **Fuel Fabrication**: A strategy for partnering with or procuring services or materials from a facility that is either currently licensed or plans to be licensed for CAT II material should be considered for applicants requiring HALEU.
Supply Chain Considerations

How might a HALEU supply chain look different from a traditional LEU fuel supply?

• Demand
  • Understanding HALEU feedstock demand and material types
  • Projecting timing and market factors

• Technical
  • Enrichment capability needs
  • Transportation

• Regulatory
  • Strategy for predictable licensing cost and schedule

• Legislative
  • Meeting Congressional directives
  • Providing necessary program support and incentives
• Inform stakeholders on current challenges associated with HALEU
  - Understanding and estimating HALEU demand
  - Enrichment, conversion, and deconversion capabilities
  - Transportation
  - Legislative and regulatory issues

• Discuss “division of labor”: where government and private roles connect

• Inform DOE of steps we should take

• Encourage all participants to work together to accomplish this “healthy marketplace” objective
• To maintain economic competitiveness, it is vital that the U.S. secure and maintain a supply

• Establishing a HALEU supply chain will require effective execution of production, transportation, and fabrication activities

• Widespread use of HALEU can have significant implications across the entire nuclear fuel cycle

• Table 1 includes Nuclear Energy Institute’s (NEI) 2020 draft data for the HALEU needs of eleven companies presented during the GAIN/NEI/EPRI HALEU Workshop in April 2020. The needs do not include enrichments below 10% for LWR fleet.

Table 1. Industry Needs – Results of NEI 2020 Survey (values in MTU)

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• Most advanced reactors under development in the U.S. will require HALEU fuel for which there are currently no domestic commercial suppliers.

• Developing the HALEU fuel cycle represents an opportunity to reinvigorate domestic mining, conversion, enrichment, deconversion, and fuel fabrication in the U.S.

• The NEI recently surveyed 11 reactor designers and developers planning to use HALEU to identify their estimated annual needs through 2030. Projected HALEU needs could reach over 50 MTU/year in 2026.

• To accelerate development of a sustainable HALEU supply capability, an initial public/private partnership is being considered to address the high-fidelity HALEU market, plus a percentage of the projected commercial demand.
Taking vital steps to help initiate and facilitate creation of a HALEU pipeline for advanced reactors

• Understanding technical, infrastructure, and regulatory needs
• Competitive awards for utilization of DOE-owned HALEU for reactor demos
• Development of head end treatment and HEU recovery systems (ZIRCEX)
• Co-funding HALEU enrichment demonstration with Centrus
NE HALEU Activities

HEU Recovery (plus down-blending)

- Accelerated treatment of EBR-II fuel (2022 – 2025) (5-10 MT)
- Exploring Hybrid ZIRCEX processing of DOE-owned fuel (2026 – 2036)

Enrichment Demonstration Program

- DOE/Centrus AC100M HALEU Cascade Demonstration, 2019-2022
- Demonstrate capability to produce HALEU with existing US-origin technology and provide DOE with a small quantity of HALEU for its use in research and development of advanced reactor concepts
- NRC License amendment allowing enrichment up to 19.75%
- 200 – 600 kg production target

Previous centrifuge setup at DOE Piketon facility
Issues

- In the traditional LWR fuel cycle, LEU is shipped in large volume containers (e.g., the 30-B container, which holds over 2,000 kg of UF$_6$) from enrichment facilities to fuel fabrication facilities
  - Such containers are limited to 5% enrichment
  - HEU containers, such as the ES-3100 and 5-B cylinder, are limited to 25 kg and are impractical for a commercial fuel cycle

- New packages, or modifications to existing packages would be required to ship HALEU in appreciable quantities (100s of kg)
  - Packages must adhere to 49 CFR 173, Subpart I and 10 CFR 71 (DOT and NRC requirements)
  - Turnaround on a design verification and amended Certificate of Compliance is expected to take around 18 months

- Lower enrichment HALEU (5 – 8%) would require a more modest modification for certifying new containers (PNNL)
NE Activities

• FY2019 and FY2020 multi-lab effort on HALEU oxide transportation package development (INL, ORNL, PNNL)
  • Initial positive feasibility evaluation of modifying larger-volume casks for transportation of HALEU oxides (INL)
  • Criticality benchmark evaluation and SCALE analysis of initial package model (ORNL)
  • Conceptual package design and developing functions, requirements, and performance specifications (All)

• Dimensions, conditions, and structural requirements for maintaining subcriticality have been established using Monte Carlo and other analysis

• FY 2020 focused on refining design specifications for potential engagement/transfer to a manufacturer

• Report to Congress on Transportation is in preparation
Three **Category III** fuel fabrication plants processing low-enriched uranium are currently licensed by the NRC:

- Global Nuclear Fuel – Americas LLC (GNF-A), Wilmington, NC
- Westinghouse Columbia Fuel Fabrication Facility, Columbia, SC
- Framatome, Inc., Richland, WA

Two **Category I** fuel fabrication plants processing up to HEU are currently licensed by the NRC:

- Nuclear Fuel Services (NFS) – now owned by BWXT, Erwin, TN
- BWXT Nuclear Operations Group, Lynchburg, VA
HALEU Infrastructure Developments and Ventures

• Centrus/X-energy Joint Venture (2017)
  • Partnership to support the design of a facility to produce advanced nuclear fuels, located at ORNL
  • Inert TRISO manufacturing of pebbles and compacts underway

• GNF/X-energy Joint Venture (2019)
  • Teaming agreement in place to develop TRISO fuel
  • X-energy TRISO production equipment, GNF's licensed nuclear fuel fabrication facility in Wilmington, NC

• BWXT (2019)
  • Announced restart and expansion of TRISO fabrication line
A reliable HALEU supply chain will require:

**Production:** Recovered/Downblended uranium in the short term, and enrichment in the long-term to establish a production capability in the time scales needed.

**Transportation:** Vertical integration of fuel cycle services, such as incorporating deconversion modules and fabrication activities with enrichment, and modification of existing transportation packages.

- OR -

Design and certification of new HALEU hexafluoride transportation containers.

**Fabrication:** facilities authorized/licensed to receive and handle CAT II material, with associated MC&A and material protection.
Roles to successfully address the barriers to create the “market draw”

- Future Users
  - Industry
  - Government
- Fuel Fabricators
- Transport System Vendors
- Enrichers/Suppliers

How are users, fabricators, transporters, and enrichers engaging with one another to address technical and infrastructure gaps?
NE wants to facilitate the best outcome:

Helping connect the “links” of the supply chain to create a diversified, competitive, and healthy HALEU fuel market

• Providing opportunities for developers
• Mitigating schedule risk by providing material for development and demonstration
• Mitigating regulatory risk by demonstrating enrichment technology