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

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High-Assay Low Enriched Uranium (HALEU)

Nuclear Energy Advisory Committee Meeting

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Addressing HALEU Needs

- Most advanced reactor concepts require HALEU (enrichments ranging from greater than 5% up to 19.75%) as a fuel source.
- Expected demands for HALEU could be potentially very significant.
- In addition, there are national missions that would require a reliable supply of HALEU.
- DOE-NE has three options under development.
  - Electrochemical Processing
  - ZIRCEX
  - Enrichment

NEI Estimated Annual Commercial Demands

- **Commercial reactor concepts require HALEU for startup core.**
- **A sustainable supply of HALEU is needed to support deployment.**

Expected commercial demands for HALEU are very significant.

NEI Estimated Annual Commercial Requirements for HALEU to 2030 (MTU/yr)

Company	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**Total**	**Cumulative**
Enrichment Range	13-19.75%	19-19.75%	10-19.75%	15.5%	19.75% and 12.6%	19.75%	17.5%	14.4%		
Year										
2018	0.001			0.025					0.026	0.026
2019	0.006	1.5							1.506	1.532
2020	0.7	1.5	0.01						2.21	3.7
2021	0.7	2.5				1.0			4.2	7.9
2022	0.7	3.0							3.7	11.6
2023	0.7	3.5	1.1		13.5				18.8	30.4
2024	0.7	5.0	1.1			3.0		0.5	10.3	40.7
2025	0.7	6.0	1.8	0.4		3.0		0.5	12.4	53.1
2026	23.3	7.0	1.8	0.4		3.0	21.4	0.5	57.4	110.5
2027	35.0	9.0	1.8	0.9		5.0	21.4	0.5	73.6	184.1
2028	46.6	11.0	1.8	1.8		25.0	21.4	0.5	108.1	292.2
2029	58.3	13.0	1.8	1.8		15.0	21.4	0.5	111.8	404.0
2030	70.0	13.5	1.8	1.8	61.0	15.0	21.4	1.0	185.5	589.5

https://www.nei.org/resources/letters-filings-comments/nei-letter-perry-need-haleu

Estimated Commercial HALEU Market Needs

Source for Industry Demand: Nuclear Energy Institute's letter to Secretary Perry, DOE (July 5, 2018)

* This projection doesn't account for potential DoD needs

Uranium Recovery and Down-blending Methods

- **Electrochemical Processing of EBR-II Spent Fuel**

- **ZIRCEX Process**

Addressing HALEU Needs - Electrochemical Processing - (EBR-II Fuel)

HEU Recovery from Used Fuel Followed by Down-blending to HALEU

- **Step 1 –** Irradiated EBR-II fuel is prepared and placed into a high temperature molten salt electrorefiner which facilitates separation of uranium metal from fission products.
- **Step 2 –** Recovered uranium undergoes vacuum distillation to remove electrorefiner salt and is down-blended to HALEU.
- **Step 3 –** The recovered uranium metal is configured to serve as HALEU feedstock by reheating and casting into low-dose uranium metal ingots.

Deliver Approximately 5 MT of 19.75 U – 10Zr Fuel by 2023

Addressing HALEU Needs – ZIRCEX Process

A three step process that recovers HEU from nuclear fuel and down-blends it to HALEU

- **Step 1 –** ZIRCEX is a dry head-end process to remove cladding (zirconium or aluminum) from nuclear fuel.
- **Step 2 –** Uranium is purified from fission products by a very compact, modular solvent extraction system. The fission products are immobilized in glass using a small in-can melt.
- **Step 3 –** The uranium is down-blended to <20 wt.% U-235 prior to solidification and fuel fabrication.

Potential Path Forward- ZIRCEX

Preliminary Schedule for ZIRCEX Process Research, Development and Demonstration Program	
Year	**Scope**
2020	Supports ¼ scale ZIRCEX head-end pilot facility. Identifies alternatives for an integrated ZIRCEX hot demonstration to include location & cost.
TBD	Supports ZIRCEX back-end pilot facility. Initiates integrated ZIRCEX hot demonstration design and layout.
TBD	Conducts integrated head-end and back-end ZIRCEX tests to support completion of ZIRCEX hot demonstration design and layout.
TBD	Initiates construction of hot demonstration process.
TBD	Completes hot demonstration construction and equipment setup.
TBD	Initiates hot demonstration tests with Type A fuel element.
TBD	Continues hot demonstration tests with Type B fuel element.

ZIRCEX Pilot Plant (1/4 Scale)

Enrichment

- Enrichment
  - Long-term sustainable approach
  - Estimated Commercial Availability 2023-2024

Demonstration of U.S. HALEU Production Capability

- U.S. Government has an opportunity to support demonstration of HALEU capability using a U.S.-owned and U.S.-controlled uranium enrichment technology at Piketon, Ohio.
- U.S. Centrifuge AC100M uranium enrichment technology is mature and technically ready for HALEU demonstration.
- DOE Operations Facility at Piketon is in excellent condition, ideally suited and immediately available for AC100M HALEU demonstration program.
- Successful outcome of the demonstration would send a signal to the market that U.S.-origin HALEU enrichment option could be available for deployment as the HALEU market evolves.

Addressing HALEU Needs - Enrichment

Description of HALEU Cascade Work Scope	FY19	FY20	FY21	FY22
Mobilize DOE facility and manufacturing, begin constructing and balancing centrifuges	X			COMMERCIALIZATION
Finish installation of centrifuges (16) and begin recycle testing		X		
Demonstrate production of HALEU, withdraw sample material			X	
DOE complete demonstration project on September 30, 2021		Run Cascade / Gram Quantity Levels	Project Completed Sept. 30, 2021	

DOE Facility

Process Building Layout

Floor Machine Mounts, Electrical, Vacuum, and Water

Questions?

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