

# HALEU Webinar

April 28-29, 2020



**EPRI** | ELECTRIC POWER  
RESEARCH INSTITUTE



**Objectives:** The High-Assay Low-Enriched Uranium (HALEU) Webinar will inform stakeholders on the status and challenges associated with HALEU for fuel fabrication and reactor development. The webinar will cover the following aspects of HALEU supply with a focus on the 10-20% enrichment range:

- Anticipated demand and timeline projections for HALEU
- Enrichment, conversion, and deconversion
- Transportation needs
- Legislative and regulatory issues

## Independent Report

GAIN/EPRI/NEI April 2020 Virtual HALEU Workshop

INL/EXT-21-61768

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# HALEU Workshop

**Objective** – Convey a team of experts from industry and national laboratories to evaluate the anticipated HALEU demand, the timing, and options.

- Co-hosted by NEI, GAIN, and EPRI with over 300 participants from 70 organizations\*
- INL developed the workshop report with contributions from U.S. uranium enrichment and downblending organizations

\*[https://gain.inl.gov/HALEU\\_Webinar\\_Presentations/Forms/AllItems.aspx](https://gain.inl.gov/HALEU_Webinar_Presentations/Forms/AllItems.aspx)

[https://gain.inl.gov/SiteAssets/2020HALEU\\_Workshop/GAIN-EPRI-NEI\\_HALEU\\_WebinarRegistration.pdf](https://gain.inl.gov/SiteAssets/2020HALEU_Workshop/GAIN-EPRI-NEI_HALEU_WebinarRegistration.pdf)



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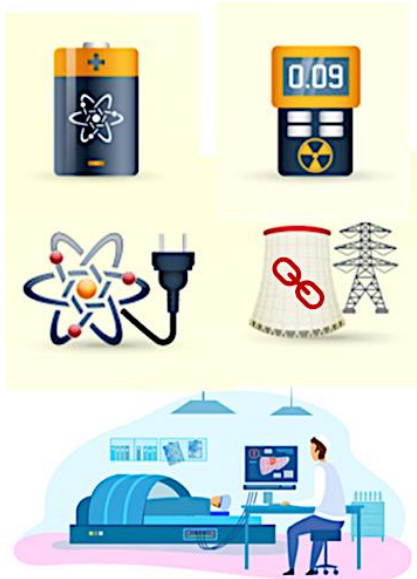
# Outline

- Anticipated Demand
- Addressing Timing
- Near-Term Options
- Integrated Supply
- “Right-Sized” Initial Capability
- Recommendations

# HALEU Anticipated Demand

## Applications

Variety of reactor designs and fuel forms



## U.S. Commercial Nuclear Industry

NEI 2020 survey HALEU results\*

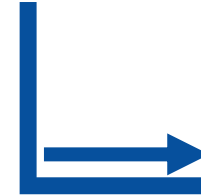
\* 2021 update available at <https://www.nei.org/resources/letters-filings-comments/updated-need-for-haleu>

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Annual HALEU MTU	2.8	3.3	9.7	12	32	64.2	32.7	50	81.7	137.3



## Government Needs

- Potential DoD mobile microreactor needs
- DOE-NE's advanced reactors demonstrations
- DOE-NE's advanced test and research reactors
- Long-term NNSA mission



## Findings

- Industry needs are the fastest growing demand for HALEU
- Government needs are predictable, High-fidelity demand is driven by medical isotope production, HEU to HALEU reactor conversions, and DoD and DOE advanced reactor demonstrations.
- Anticipated demand for HALEU comes from a variety of applications requiring a variety of uranium fuel forms including oxides, metal and alloys, and nitrides and carbides

# Timing - Transitioning to a Sustainable Market

## What is needed for a Sustainable Market?

- A large enough customer base
- Securing long-term purchase agreements
- Fuel procurement models
- Infrastructure financing tools

HALEU Demand



## Findings

- The timing is influenced by when and which reactor concepts mature toward commercialization
- Transitioning from “early movers” to a “sustainable” market would be a gradual evolutionary approach
- The timing is not predictable

# Limited Near-Term Domestic Options ~ 20MT (mid 20's)

*Supporting Early Movers - An aggressive deployment schedule is being pursued by advanced reactor developers eager to penetrate an evolving world market*

<b><i>Recovery and Downblending</i></b>	
INL	1MT of HALEU per year until 2035. HEU downblending from EBR-II and ATR origin yields 10MT and 20MT
SRS	Potential 20MT HALEU available from fuel take back processing
BWXT	Potential 10MT by 2022 and 40MT by 2025. Downblending excess/surplus HEU
<b><i>Enrichment</i></b>	
American Centrifuge Operating LLC	600 kgs of UF <sub>6</sub> ongoing 16 machine cascade demonstration
URENCO USA	Commercial enrichment facilities for HALEU enrichment between 5% and 10%



## Limitations

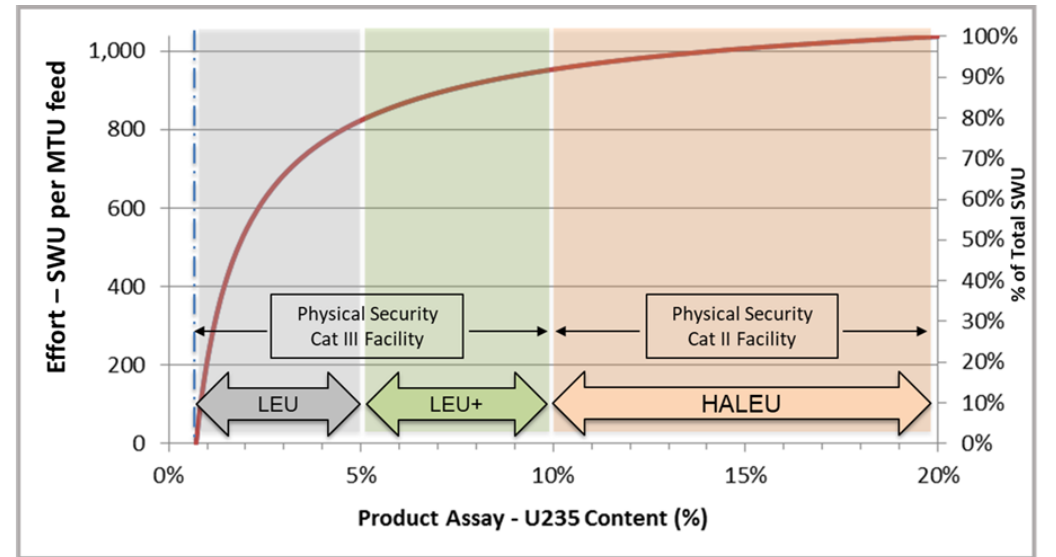
- Some early movers are not able to use recovered materials
- Some early movers are not able to receive UF<sub>6</sub> as the feedstock
- Near-term options have limited or no funding

***Enrichment is key to long-term HALEU supply***

# Integrated Supply Enrichment Option

Production of HALEU enriched above 10% requires significant investments to support license, build, secure and operate HALEU fuel cycle infrastructure.

- Impacted facilities that support a HALEU fuel cycle economy are enrichment, deconversion, and fuel fabrication
- If facilities are not co-located, there is also a significant impact from transportation



U235 Enrichment Levels

Feed 0.711%  
Natural Uranium

LEU <5%  
Existing LWRs

LEU+ 5% - 10%  
Metallic Fuels & ATFs

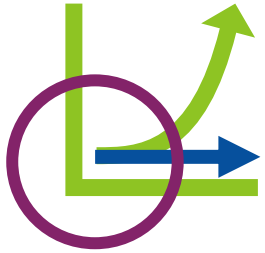
HALEU 10% - 20%  
Test, Research and  
Gen IV Reactors

## Findings

- Maximizing utilization of LEU (expanded to LEU+) enrichment infrastructure will significantly decrease the size of a HALEU Category II enrichment facility, resulting in lower costs and more competitive production of HALEU.
- Deconversion of HALEU enriched above 10% must also be conducted in a physical security Category II facility. Co-location of HALEU facilities (enrichment, deconversion, and fuel fabrication) with an LEU enriching facility decreases the cost of transportation and leverages security costs. Co-location of facilities will result in the most economic HALEU production model.



# “Right-Sized” Initial Capability



Initial HALEU capability could “prime the pump” for a future market driven by commercial needs and sized to meet the “high-fidelity” market demand and a portion of the initial commercial needs.

## Findings

- Although a portion of the high-fidelity demand is currently being addressed by downblending government-owned HEU stocks, these stocks are valuable assets.
- If another source of HALEU existed today, government-owned stocks would be preserved to support and extend government missions.
- Commercial demand for HALEU in the next 10 years could be much larger but is more uncertain. Modular design concepts could accommodate future growth.
- Enrichment technology is well suited for future modular expansion



**Near-term, predictable HALEU “high-fidelity” demand mainly supports government agencies’ demonstration projects and mission needs driven by:**

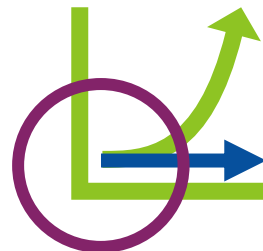
- *Medical isotope production*
- *HEU to HALEU research reactor conversion*
- *DoD microreactor demonstration*
- *DOE’s advanced reactor demonstrations, test and research reactors*

**Some needs are currently met by downblending limited HEU government-owned stocks.**



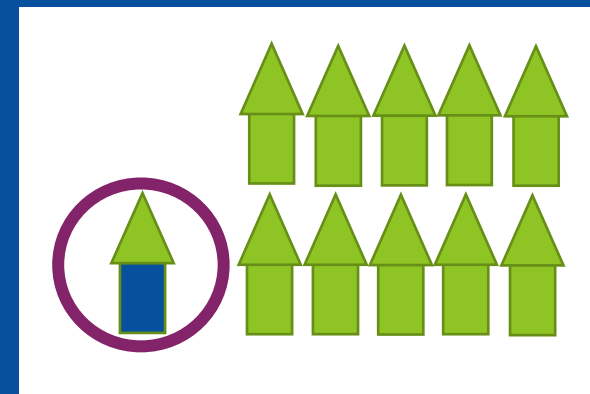
# Recommendations

An initial public/private partnership is recommended to address the high-fidelity HALEU market, plus a percentage of the projected commercial demand.



- It is predicted that by the mid-2020's approximately 22 MTU will be needed for initial core loadings to support DoD and DOE's reactor demonstrations and DOE test and research reactors\*.
- The high-fidelity HALEU demand is estimated to be between 8-12 MTU annually for the next 10 years.
- A pricing model that accounts for the added cost of going from LEU (or LEU+) to HALEU should be established.
- A mechanism such as a lease model, wholesaler, or reserve should be developed to make HALEU available to support commercial needs.

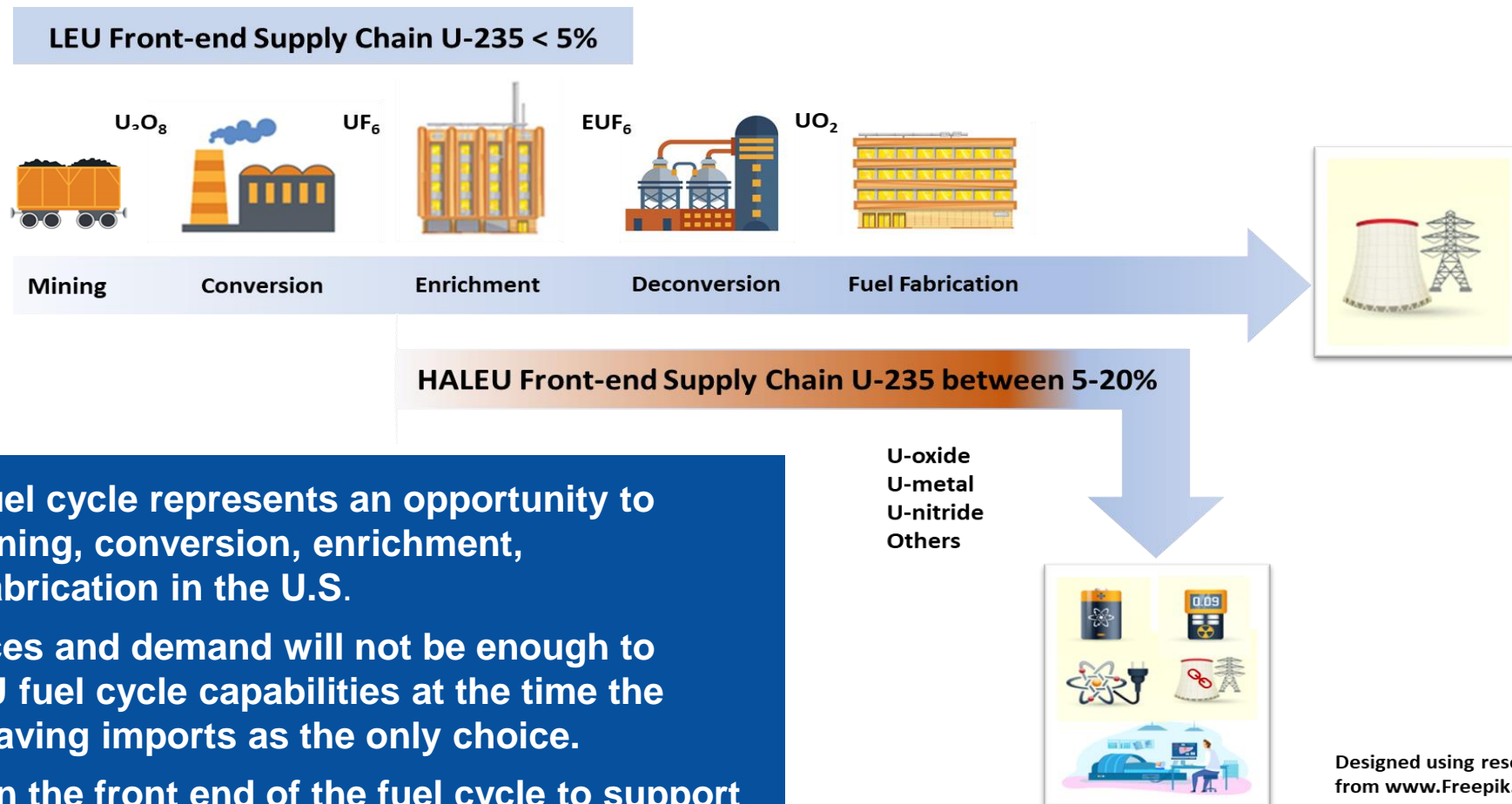
\* As of June 2020, quantities may vary, but will not differ significantly to change the initial HALEU capability recommendation.



**Given the variety of HALEU applications, the initial HALEU capability must be flexible and able to accommodate:**

- Uranium enriched up to 10% U-235 as the feed
- Enrichments of U-235 varying from 10 to 19.75%
- Supply HALEU at a minimum annual rate of 12 MTU
- Modular design concepts to accommodate future growth
- Deconversion of  $UF_6$  to a form (e.g., uranium oxide) suitable for production of a variety of uranium fuel forms, to include oxides, metal and alloys, and nitrides and carbides.

# Closing



- Developing the HALEU fuel cycle represents an opportunity to reinvigorate domestic mining, conversion, enrichment, deconversion, and fuel fabrication in the U.S.
- Relying upon market forces and demand will not be enough to create the needed HALEU fuel cycle capabilities at the time the industry will require it, leaving imports as the only choice.
- Commercial investment in the front end of the fuel cycle to support HALEU production will not be made on a speculative basis.



Idaho National Laboratory