GAIN Gateway for Accelerated Innovation in Nuclear

The ZIRCEX process pilot plant at INL's INTEC facility

Hybrid Zirconium Extraction (ZIRCEX) Process

Recovering and downblending HEU from federally owned fuels

DOE's HALEU Program enables deployment of advanced reactors to help secure America's clean energy future.

What is HALEU?
High-assay, low-enriched uranium. Uranium containing between 5% and 20% U-235.

Why is HALEU needed?
Fosters advanced reactor development and supports better nuclear power plant economics.

What are the HALEU sources?
Long-term – Enrichment
Interim – Downblending current and/or recovered highly enriched uranium (HEU) in the federal complex. HEU contains 20% or more U-235.

The hybrid ZIRCEX (short for zirconium removal prior to extraction) process recovers highly enriched uranium (HEU) and downblends it to create High-Assay Low-Enriched Uranium (HALEU), defined as uranium containing between 5% and 20% U-235.

Why ZIRCEX?

Previous recovery of HEU from irradiated fuels utilized liquid head-end processes that dissolved the entire fuel element (including cladding material) creating a large amount of secondary waste. This is avoided as ZIRCEX is a dry head-end process, which reduces the amount of liquid waste by a factor of over 1,000. In addition, any residual liquid waste is solidified by vitrification, eliminating liquid waste.

The Hybrid Process

The process feed is composed of previously irradiated fuels in the federal complex and incorporates three steps:

- ***Step 1*** – Cladding (zirconium or aluminum) is removed from nuclear fuel by the ZIRCEX dry head-end process.
- ***Step 2*** – Uranium is decontaminated from fission products by a very compact, modular solvent extraction system. The fission products and other residues are immobilized in glass using a small in-can melt.
- ***Step 3*** – The uranium is downblended to between 5% and 20% U-235, prior to solidification and fuel fabrication.

ZIRCEX to date

INL first conducted laboratory scale testing with unirradiated zirconium alloy to determine operating parameters for irradiated fuel samples. The parameters were used to conduct irradiated fuel samples tests which successfully determined that reaction rates for irradiated and unirradiated fuel were comparable. This is important as working with unirradiated materials allows for expeditious testing, resulting in shorter research and development time.

Currently, INL is using a one-fourth scale pilot facility to conduct research and development of the ZIRCEX process on unirradiated materials which will inform the integrated hybrid ZIRCEX process demonstration.

How do we transition from a LEU to a HALEU Fuel Cycle?
Infrastructure updates are needed to address safety, safeguards and security. Companies making investments need a robust HALEU market. Advanced reactor developers require HALEU to test their concepts, which in turn create the HALEU market.

This research-and-bridge role is a familiar one for DOE. The agency has been instrumental in advancing technologies for renewables and other energy types.

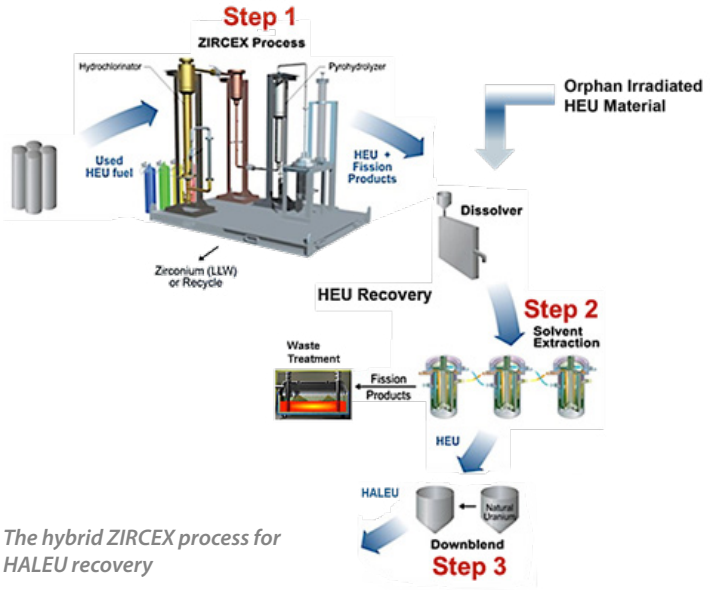
National Lab Partnership

INL is working with DOE national laboratories integrating their expertise in the development of the hybrid ZIRCEX process. The partnership supports the hybrid process decontamination and downblending steps. Key partners include:

- Argonne National Laboratory – Solvent Extraction
- Pacific Northwest National Laboratory – Waste Treatment
- Oak Ridge National Laboratory – Product Solidification

Path Forward

INL is currently conducting testing of the one-fourth scale ZIRCEX pilot plant, while evaluating testing and demonstration of the hybrid ZIRCEX process using irradiated materials with its laboratory partners



The hybrid ZIRCEX process for HALEU recovery

For more information

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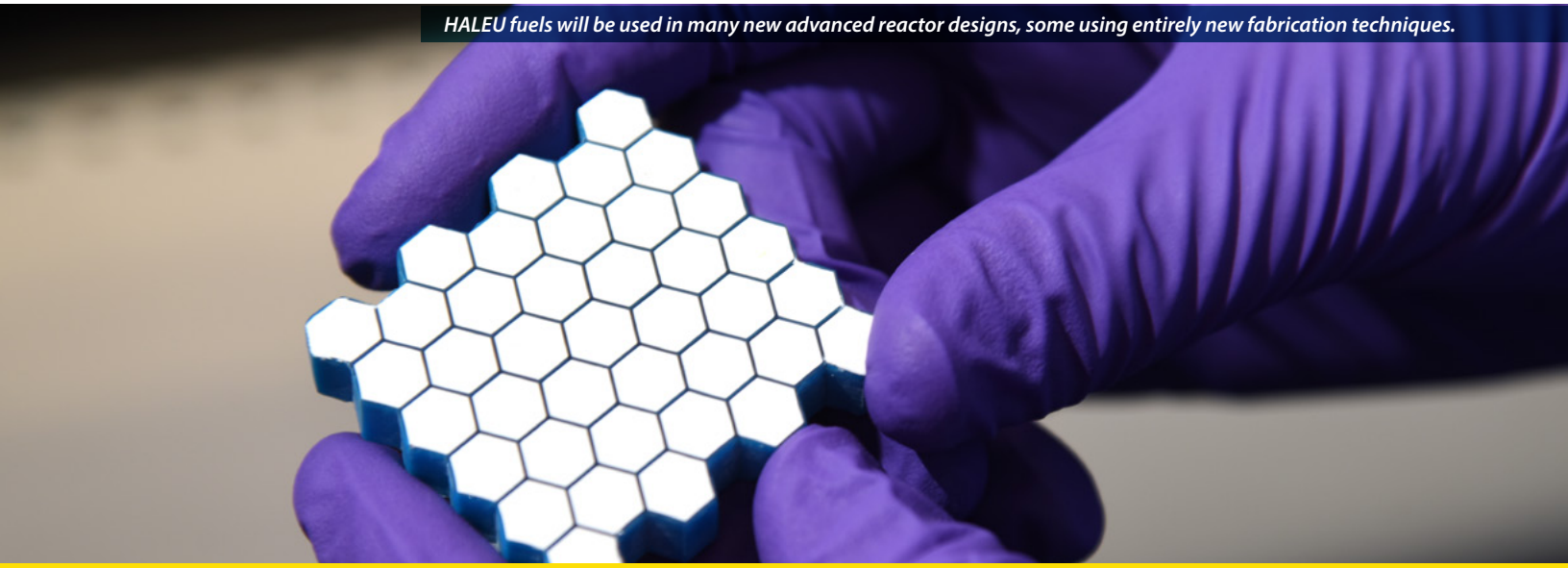

HALEU fuels will be used in many new advanced reactor designs, some using entirely new fabrication techniques.