U.S. DEPARTMENT OF ENERGY | Nuclear Energy

Fuel Cycle Research and Development

Fuel Cycle R&D Separations and Waste Form Campaign

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Separations and Waste Form Campaign

NEUP Webinar
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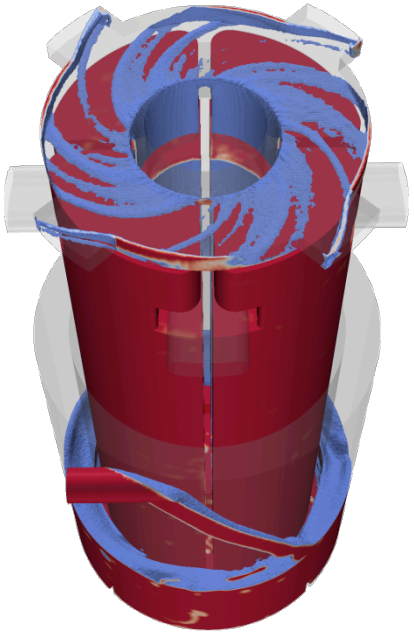
Campaign Objective

- **Develop advanced fuel cycle separation and waste management technologies that improve current fuel cycle performance and enable a sustainable fuel cycle, with minimal processing, waste generation, and potential for material diversion**
  - *Our job is to develop viable and economic technical options that will inform future decisions on the nuclear fuel cycle*



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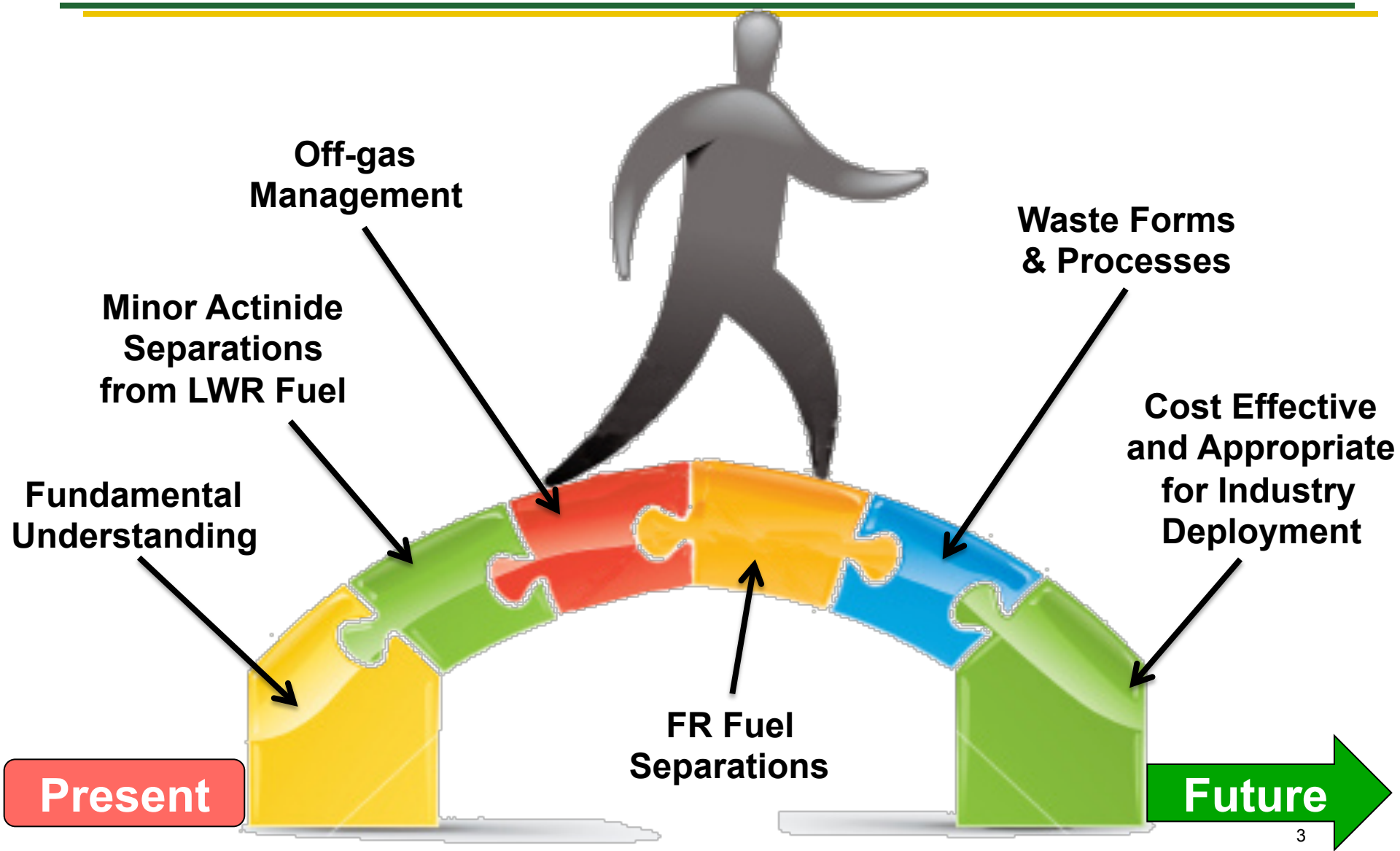
Full Recycle Technology Gaps



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Objectives of Major Separations R&D Areas

Advanced Aqueous (AA)	• ***Develop and demonstrate technologies applicable over a broad range of aqueous separation methods***
Minor Actinide Sigma Team (MA)	• ***Enabling technology for TRU recycle options from LWR fuel*** • ***Develop cost effective technology ready for deployment***
Off-gas Sigma Team (OG)	• ***Enabling technology for any recycle option*** • ***Develop cost effective technology ready for deployment***
Fundamental Science / Mod. & Simulation (FS&M, M&S)	• ***Develop advanced methods to develop fundamental understanding of separation methods, waste forms, and waste form performance- develop predictive models based on fundamental data***
Separation Process Alternatives (ASP)	• ***Investigate alternative process options to determine if significant cost or performance improvement can be realized***
Alt. Waste Forms and Characterization (AWF, WFC)	• ***Open disposal options with higher performance waste forms*** • ***Develop cost effective technology ready for deployment***
Uranium Extraction from Seawater (FR)	• ***Develop and demonstrate extractants and engineered systems with double the capacity over current technology***
Electrochemical Processing (DE, JFCS)	• ***Develop and demonstrate deployable and sustainable technology for fast reactor fuel reprocessing***

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Campaign Research Needs

- Development of fundamental understanding of advanced aqueous or electrochemical separation methods for the separation of transuranic elements (Np, Pu, Am, and/or Cm) including the development and validation of predictive modeling approaches based on fundamental data rather than empirical approaches;
- Development of novel “out of the box” separation methods that have the potential of significantly reducing complexity and cost of processing fuel while reducing proliferation risk and waste generation;
- Development of new materials for the effective capture and/or immobilization of gaseous fission products released during UNF processing.
- Innovative waste forms with orders of magnitude higher chemical durability and equal of lower processing costs compared to currently-employed waste forms such as borosilicate glass particularly for long-lived fission products such as iodine-129 and technetium-99 and for grouped fission products high-level waste.
- Application of nano-materials unique properties to revolutionize separations methods for actinides and lanthanides or fission gasses such as iodine.
- Fundamental understanding of waste form performance over geologic time scales; particularly for waste glasses and iron-based alloys.

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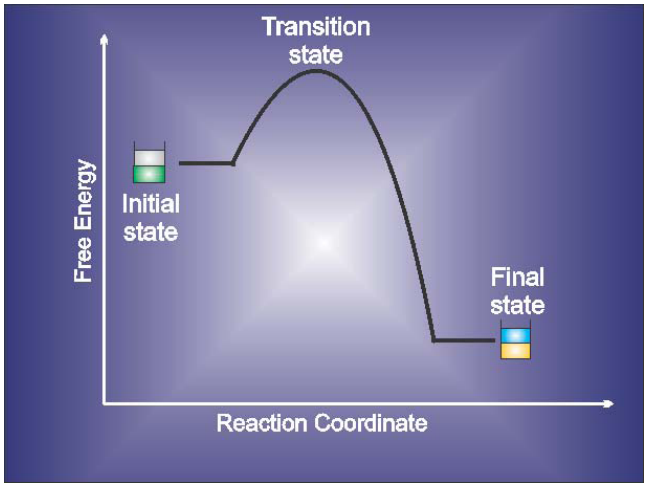
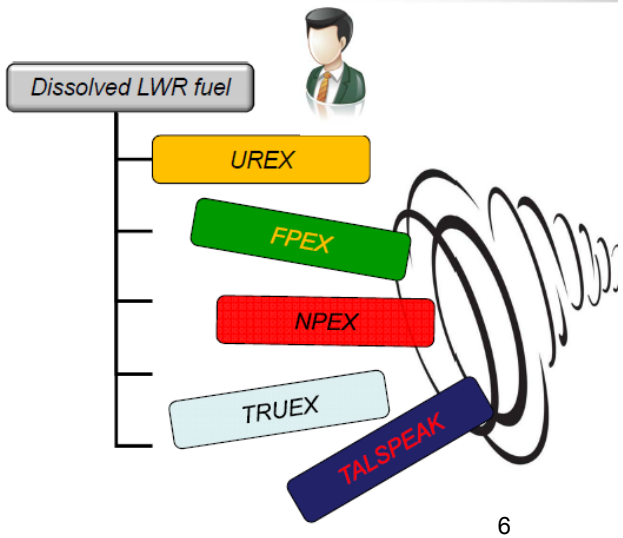
Campaign Research Needs

- **Develop Fundamental Understanding of Separation Processes**
  - Development of fundamental understanding of advanced aqueous or electrochemical separation methods for the transuranic elements (Np, Pu, Am, and/or Cm)
  - Develop and validate predictive modeling approaches based on fundamental data rather than empirical approaches
    - *Elucidate fundamental properties of advanced separation processes which will enable development of more robust separation technologies as well as predictive models*
    - *Develop understanding of process operational envelopes as well as process limitations (e.g. pH, temperature, etc.)*
- **Novel Separation Methods**
  - Investigate new technologies that have the potential to be simpler, more robust and more cost effective for the separation of TRU elements





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Campaign Research Needs

- **Fission gas capture and immobilization:**
  - innovative methods to manage H-3 in an aqueous reprocessing scheme are needed
    - *current efforts focus on voloxidation to remove H-3 from the fuel prior to aqueous dissolution*
    - *options for H-3 removal from high volume water streams or other potential management options*
  - methods for managing I-129 in aqueous reprocessing scheme
    - *DF's on the order of 10,000 for the overall plant are needed*
    - *Both high concentration low-flow streams and low concentration high-flow streams*
    - *Need waste forms that are both cost effective to fabricate starting with capture media and fractional release rates on the order of 10^{-8} y^{-1} in a variety of disposal environments*
  - krypton management methods
    - *methods to separate Kr from gas streams without requiring cryogenic temperatures are desired*
    - *storage forms that can safely store Kr for 30 years in the presence of high heat and reactive Rb liquid metal from Kr-85 decay.*

Regulation	^{85}Kr	^{129}I	^{3}H	^{14}C	Dose to public (mrem/y)
40CFR190 (Ci/GWye)	$5x10^{4}$	$5x10^{-3}$			75 to thyroid 25 any other organ
10CFR20 (Ci/m^3 site boundary)	$7x10^{-7}$	$4x10^{-11}$(air) $2x10^{-7}$(water)	$1x10^{-7}$ (air) $1x10^{-3}$ (water)	$3x10^{-7}$	100

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Campaign Research Needs

- **Innovative waste forms**
  - suitable waste forms exist for high-level waste raffinate however advanced waste forms with significant improvements in waste form durability (e.g., orders of magnitude improvement) and fabrication cost (e.g., > 30% cost reduction) will make waste management systems more efficient
    - *innovative waste forms and processes that can simultaneously reduce cost and increase durability are sought*
    - *waste forms for I-129, TRU, and grouped fission products should be the primary focus*
    - *waste forms for electrochemical salt wastes containing fission products and trace TRU are also a primary focus*
- **Fundamental understanding of waste form performance over geologic time scales**
  - for waste forms to be suitable their durability must be good but also predictable current high-level waste forms have several orders of magnitude uncertainty in long-term performance
    - *developing a fundamental understanding of waste form performance in their disposal environments is key to the success of waste forms*
    - *efforts to combine theory, experiment, and modeling to better understand the performance of waste forms is needed*
    - *the performance aspects of interest include resistance to aqueous attack, stability under high-temperature and high radiation fields (including self-decay), and evolution of effective waste form surface area*

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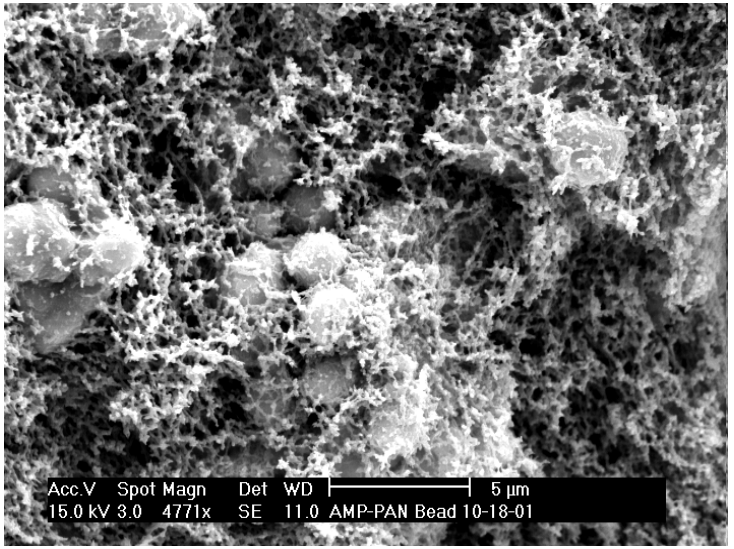
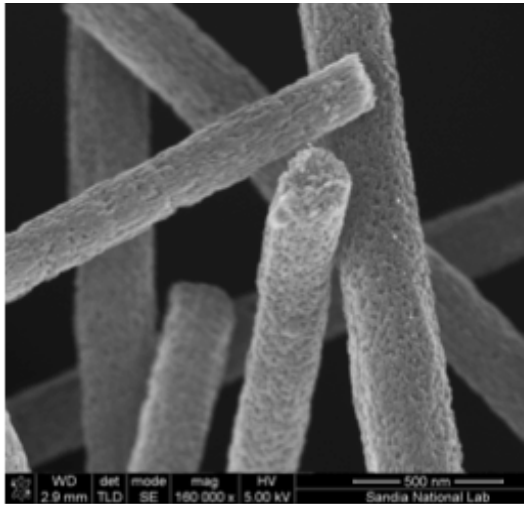
Campaign Research Needs

- **Nanotechnology**
  - Investigate the unique properties of nanomaterials that may offer improvements in advanced separation methods
  - Development of novel materials to enhance separation of trivalent actinides from lanthanides
  - Development of novel materials to capture fission gas materials such as iodine
  - Development of advanced nanomaterials that may offer improvements in waste forms





Summary

- The FCR&D Separations and Waste Form (SWF) Program wants to partner with universities to enhance their R&D portfolio and research capabilities
- This call is tailored to research topics that are well suited for university research
- The SWF program seeks university researchers who want to actively participate in the SWF program and enhance interactions with national laboratory research staff