



U.S. DEPARTMENT OF  
**ENERGY**



# Update on the German Graphite Fuel Project

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# Background

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- **At the request of the German government in February 2012, the Office of Environmental Management (EM) began evaluating the viability of the accepting graphite spent nuclear fuel (SNF), containing ~900 kilograms of U.S.-origin highly enriched uranium (HEU), resulting from irradiation in two German High Temperature Gas-Cooled Reactors**
- **In April 2014, DOE signed a Statement of Intent with the German government to continue to evaluate the possible acceptance of this fuel including conducting a National Environmental Policy Act (NEPA) review**
- **The return of this material supports the US policy objective to reduce, and eventually eliminate, HEU from civil commerce and is consistent with US nonproliferation policy**
- **German government has funded all technology development work, including NEPA review**

# Source of Material

- **US origin HEU material was provided for purposes of peaceful uses and development of nuclear energy**
  - Explored the use of coated fuel particles embedded in graphite spheres, used in pebble-bed reactors, cooled by helium (high temperature gas-cooled reactor, HTGRs)
- **Used in two reactors in Germany**
  - AVR Reactor (1967-1988) was the first high temperature reactor in Germany to test the technology of graphite spheres
  - THTR-300 (1983-1989) was a demonstration research reactor to prove the AVR concept design to produce electricity

graphite UNF spheres

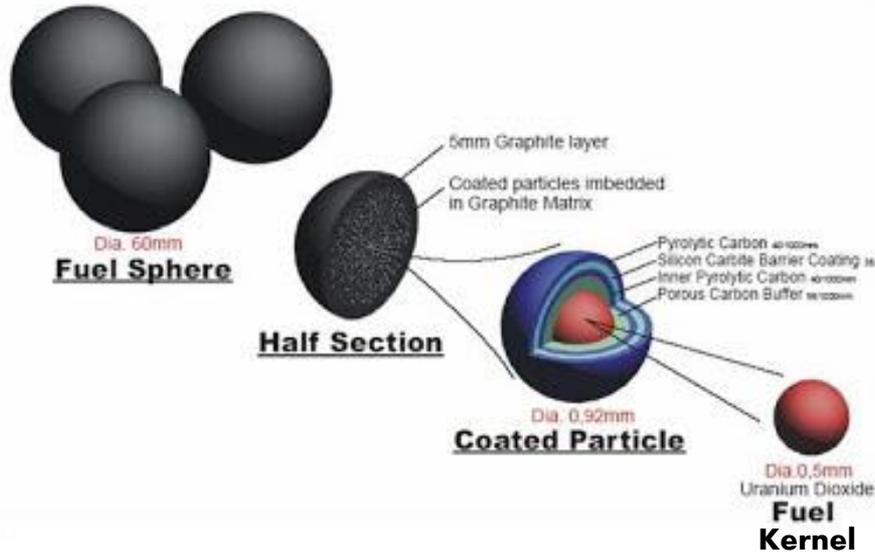


AVR Research Reactor,  
15MW(e), Jülich



THTR-300, Prototype Research  
Reactor, 300 MW(e),  
Hamm-Uentrop

# Composition of German HEU Fuel



- **Approx. 1 million, 60mm graphite spheres**
- **Characteristics of a sphere:**
  - ~ 200 g of A3-3 graphite
  - 1g of uranium, ~93% enriched
  - 10g of thorium
- **Currently stored in 455 CASTOR casks:**
  - AVR (Jülich)
  - THTR-300 (Ahaus)

# CASTOR Casks

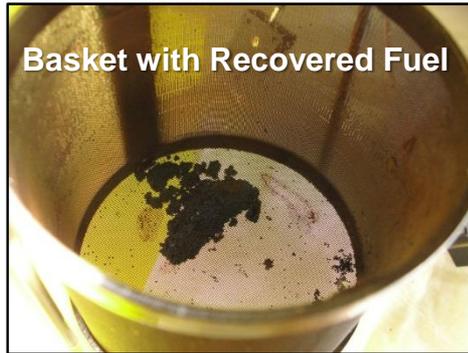
- Casks are certified in Germany by the German equivalent to the US Nuclear Regulatory Commission (NRC)
- Casks have been reviewed and approved by the NRC for acceptance as DOE/US Department of Transportation (DOT) - certified Type B casks



CASTOR Cask cut away

# Technical Efforts to Date

- Separation of fuel kernels from the graphite matrix was a concern for processing
- Funding for Research and Development (R&D) was provided by Forschungszentrum Jülich (FZJ).
- Savannah River National Laboratory (SRNL) R&D focused on chemical digestion of the graphite, results to date are very successful
- Next research steps are to validate the technologies for scale-up and optimization.
- Environmental Assessment was conducted on the options for the German Pebble Bed Reactor fuel if it is returned to the United States.



Recovered Fuel  
Kernels from  
Digested Pebble

# Environmental Assessment Summary

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EM has prepared and issued the *Final Environmental Assessment for the Acceptance and Disposition of Spent Nuclear Fuel Containing U.S. – Origin Highly Enriched Uranium from the Federal Republic of Germany (DOE/EA-1977)*

- Analyzed the potential environmental impacts from receipt, storage, processing, and disposition of graphite SNF at the Savannah River Site (SRS)
- ~1,000,000 graphite fuel elements containing ~900 kilograms (prior to irradiation) of U.S.-origin HEU
- Based on analysis in the EA, determination of a FONSI regarding the proposed action was derived
- Issuance of EA and FONSI does not constitute a decision or commitment from DOE to accept the graphite SNF from Germany

# Path Forward

- **Before a decision on viability of accepting this fuel can be made, certain key steps must be completed:**

- Completion of NEPA review 
  - *EM issued the Final Environmental Assessment and Finding of No Significant Impact (FONSI) on December 20, 2017*
- Carbon digestion technology must be proven in a pilot scale plant - Technology Readiness Level (TRL) – 6
  - *Technology currently at TRL-4*
  - *With the issuance of the FONSI and the desire to continue technology development, we are working with Germany to establish the contractual agreement to achieve a pilot scale demonstration (TRL 6)*
- DOE and German government must agree on cost for receipt, processing, and disposition of the fuel, e.g. full cost recovery
- H-Canyon must be available for processing of the fuel

# Next Steps

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- **Work for Others agreement completion time was extended until March 31, 2018**
  - Allows for the work for others contract to remain valid until a revision can be put in place
- **Receive additional funding (\$1.9M) for these activities**
  - Revision of the Work for Others to address next research activities and updated schedule and cost estimate for complete project scope
    - *Focus on offgassing and evaluation of utilizing lower operating temperatures*
- **DOE working with JEN to establish a contract for the Technology Maturation required to reach Technology Readiness Level 6 (Pilot Scale)**

**Back Up**

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# Areas Analyzed

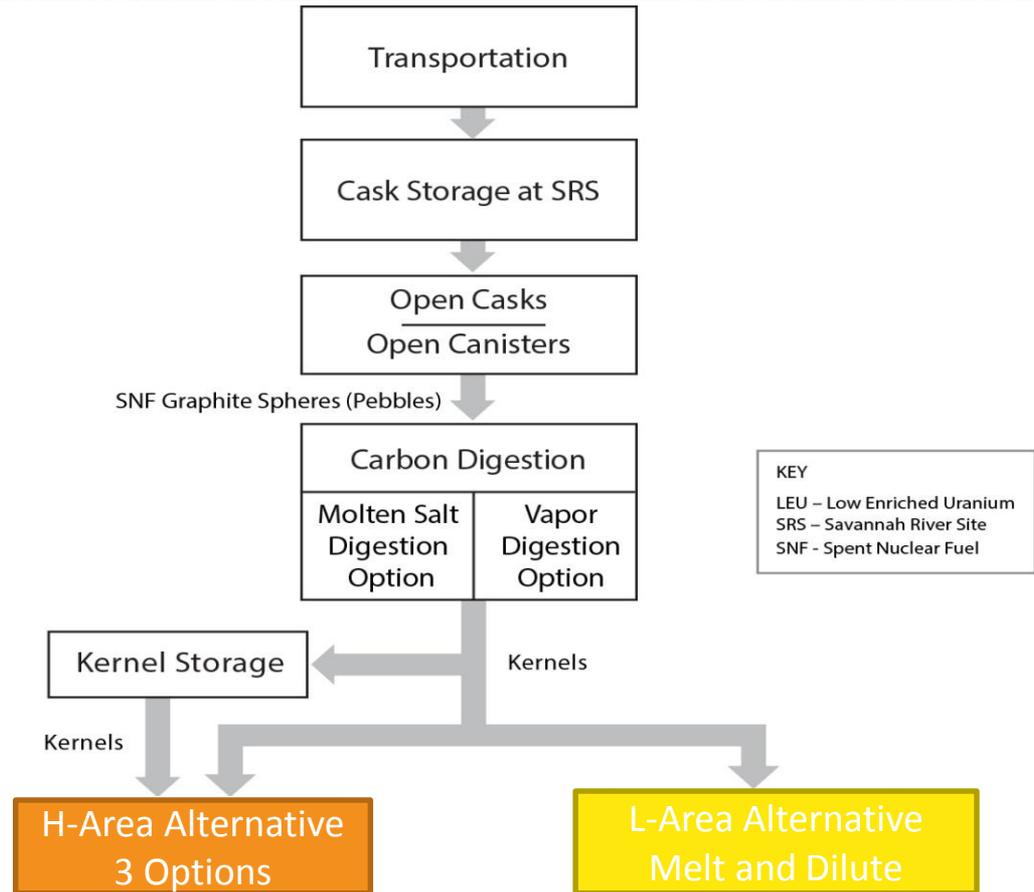
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- Impacts on air quality
- Impacts on general population and workers
- Impacts that could occur as a result of postulated accidents and intentional destructive acts (terrorist actions and sabotage)
- Socioeconomic effects
- Potential disproportionately high and adverse effects on low-income and minority populations (environmental justice)
- Impacts from transportation of radioactive materials, including transport across the ocean
- Impacts on waste management activities
- Short- and long-term land use impacts, including potential impacts of disposal
- Cumulative impacts
- Other resource areas also analyzed for SRS

# Alternatives Evaluated

- No Action Alternative (NEPA baseline)
- H-Area Alternative
- L-Area Alternative

**Both action alternatives require the use of the Carbon Digestion Technology (under development by SRNL)**



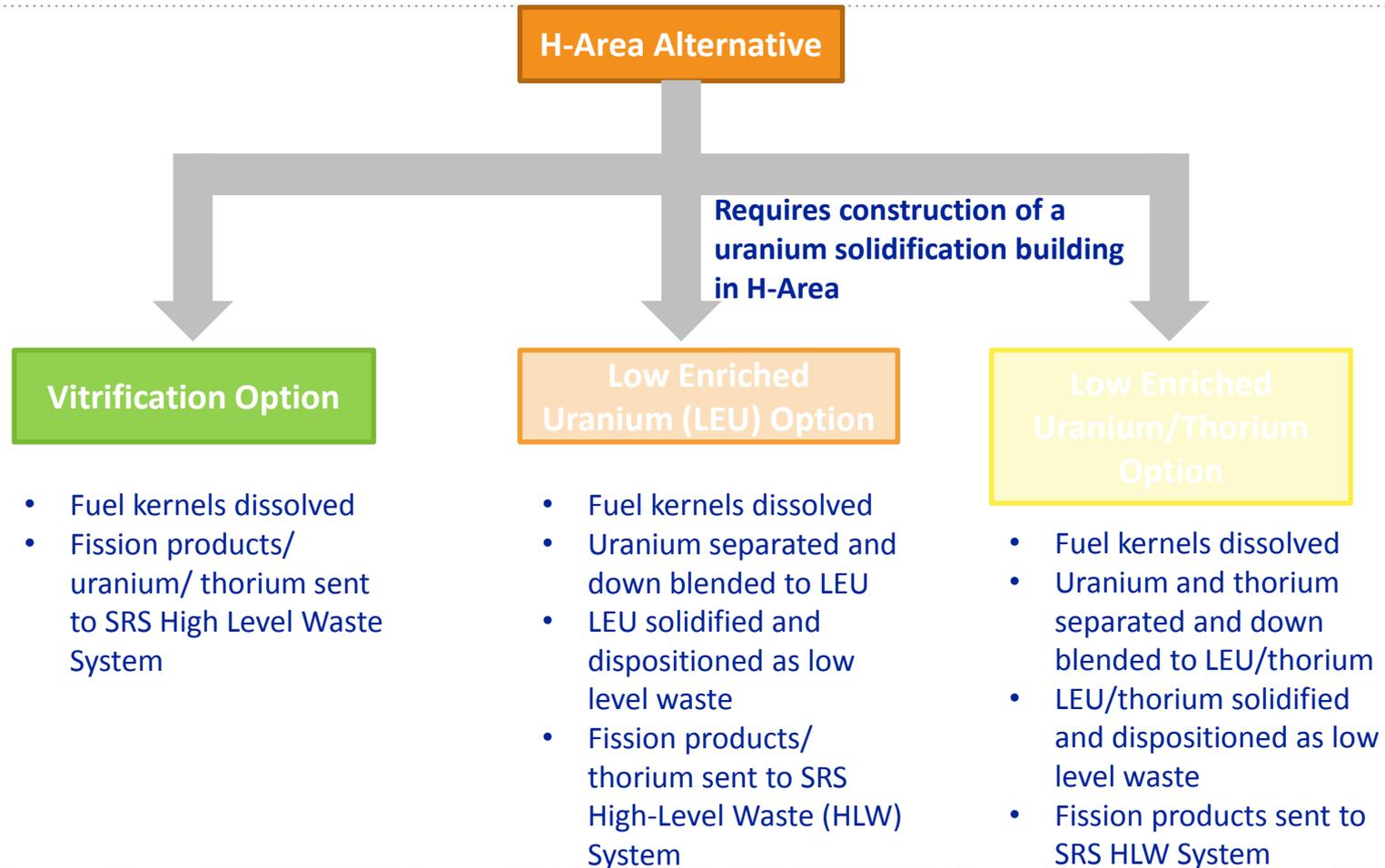
# Stakeholder Involvement

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Extensive stakeholder involvement process was undertaken in developing the EA, above and beyond what is required

- DOE held two public meetings in North Augusta, South Carolina
  - Notice of Intent to prepare an EA, June 24, 2014
  - Issuance of Draft EA, February 4, 2016
    - DOE granted a two-week extension to the public comment period which ended March 25, 2016 to accommodate stakeholders' requests
- Several meetings with SRS Citizens Advisory Board and South Carolina Governor's Nuclear Advisory Council to provide updates
- Communication with key congressional leaders during issuance of draft EA; as well as with planned issuance of final EA and FONSI

# H-Area Options Evaluated



# L-Area Alternative Evaluated

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## L-Area Alternative Melt and Dilute

- Kernels down blended to a low-enriched uranium mixture (kernels would not be dissolved as in the H-Area Alternatives)
- Low-enriched uranium mixture melted and cast to uranium-aluminum alloy ingots
- Ingots stored in concrete overpacks on a storage pad in L-Area awaiting a Federal Repository

Requires construction and building modifications in L-Area: sand filter, fan room, stack, and truck bay