U.S. DEPARTMENT OF ENERGY

SRS

Update on the German Graphite Fuel Project

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Background

- 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

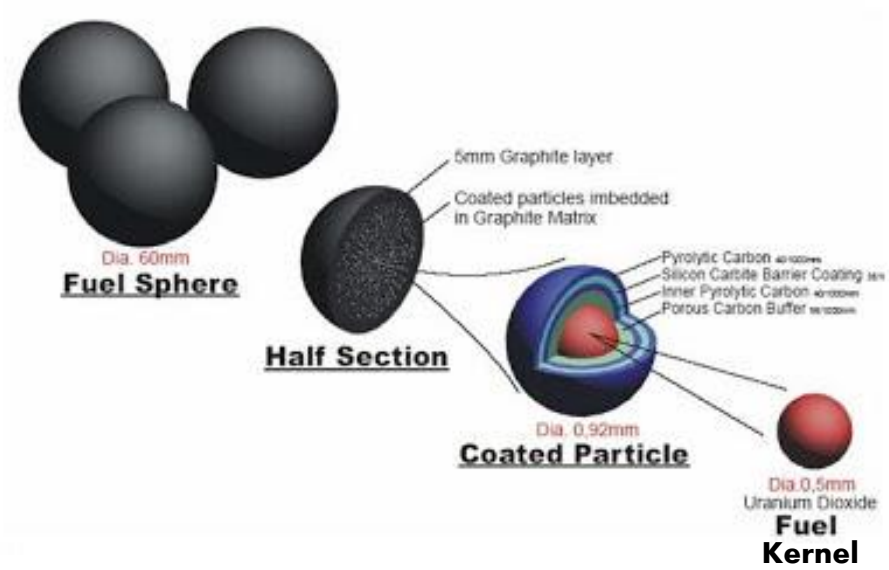
- **US origin HEU material was provided for purposes of peaceful uses and development of nuclear energy**
  - Explored the use of coated fuel particles embedded in graphite spheres, used in pebble-bed reactors, cooled by helium (high temperature gas-cooled reactor, HTGRs)
- **Used in two reactors in 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

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

- **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

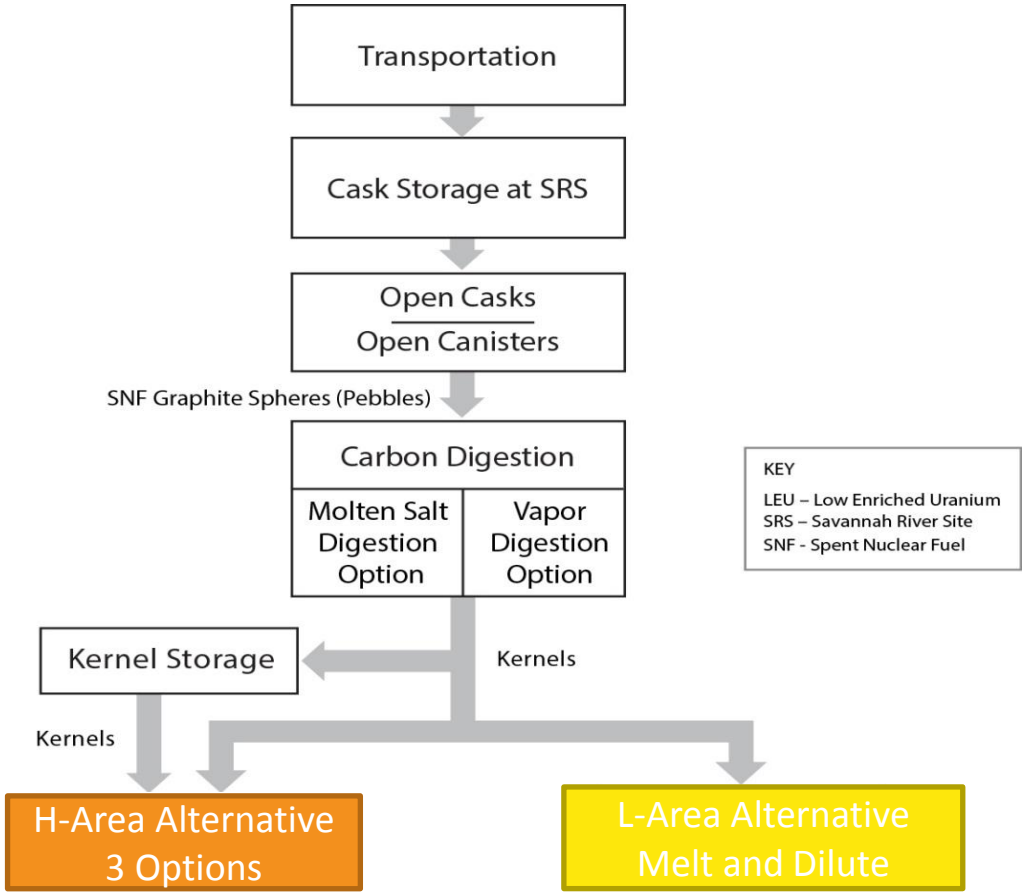
Areas Analyzed

- 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)

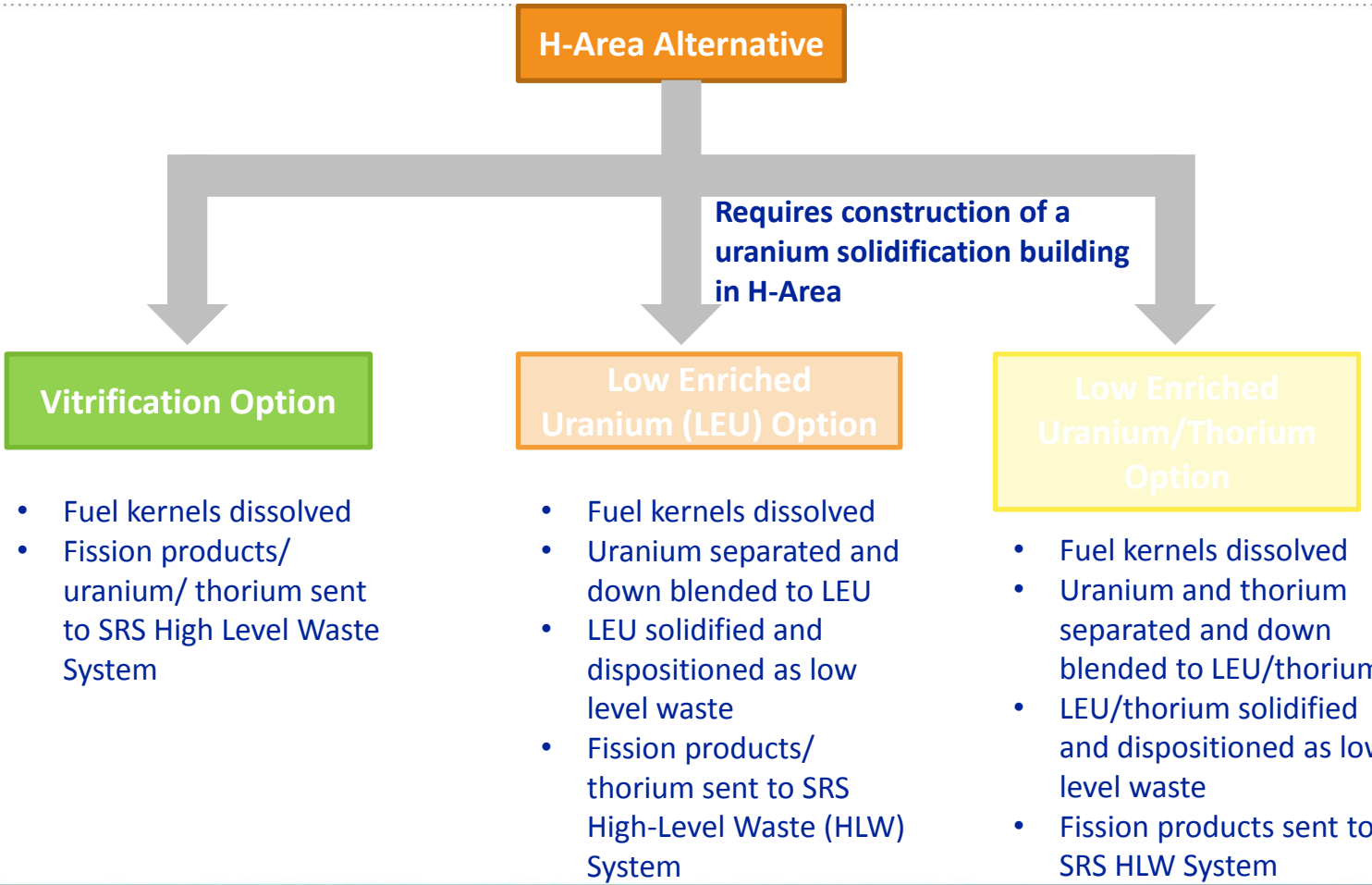


Stakeholder Involvement

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

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