



HALEU Fuel Manufacturing for Microreactor Workshop

June 2019

Changing the World's Energy Future

Doug Crawford



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**Prepared for the
U.S. Department of Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517**

HALEU Fuel Manufacturing



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**GAIN-EPRI-NEI-USNIC
Micro-Reactor Workshop**
June 19, 2019 – Idaho Falls, ID

INL Fuel Fabrication



- **Pu and minor actinides**
 - Fuel Manufacturing Facility (FMF)
 - Casting Laboratory (Analytical Laboratory)
- **Uranium**
 - Fuels and Applied Science Building (FASB)
 - Experimental Fuels Facility (EFF)



Transuranic glovebox line in FMF

Advanced Fuels Campaign

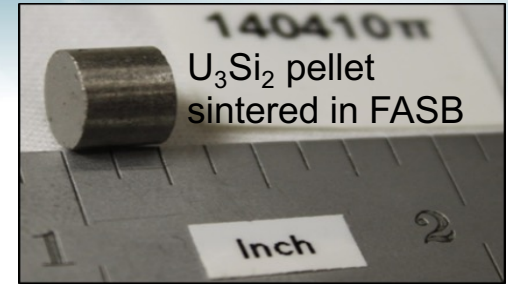
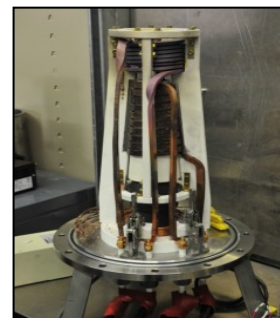


Metallic fuel extrusion line in EFF

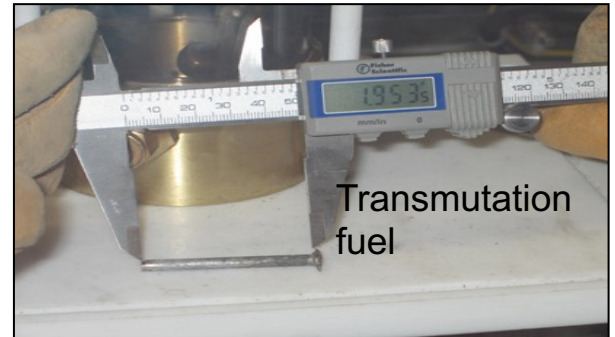
TerraPower



Fuel casting furnace in FASB (U capability in EFF)



Fabrication development of accident tolerant fuel (U_3Si_2)



Fabrication process development – casting of metal fuel



Fuel experiment capsule (top) and rodlets ready for irradiation testing

Advanced Nuclear Needs Near-term HALEU Fuel for Demonstration

- **Several new reactor and fuel concepts call for use of high-assay low-enriched uranium (HALEU) fuel (U-235 enrichment from 5% to 20%)**
 - Regulatory approval may be facilitated by demonstration
 - But – no commercial HALEU supply of or capability
 - DOE and INL asked to help provide HALEU fuel
- **Insufficient DOE uranium inventory available for this purpose, so ~10 MT of HALEU from FCF spent fuel treatment to be made available**
- **DOE-funded study at INL-MFC**
 - HALEU recovery using the FCF process
 - Fuel fabrication in INL facility using gloveboxes, rather than in shielded hot cells
 - Consider generically metallic fuel and pellet-type fuel engineering-scale fuel manufacturing campaigns



Facility Options

- **Targeting Haz Cat 2 authorization**
- **MFC-798 (RLWTF)**
 - Available in late 2019
 - Need to remove contaminated piping and equipment
- **FCF Mockup Shop Area**
 - Need to first relocate current mission
 - Access restricted by security requirements
- **ZPPR Reactor Cell & Workroom**
 - Available now
 - Limited ventilation capacity and floor space
- **EBR-II Dome**
 - Best used for reactor demo?
 - Need to repair Dome & Shell and install reinforced concrete floor
- **All need HVAC work and other system mods/installs**



For Quickest-possible HALEU Fuel Delivery We Propose

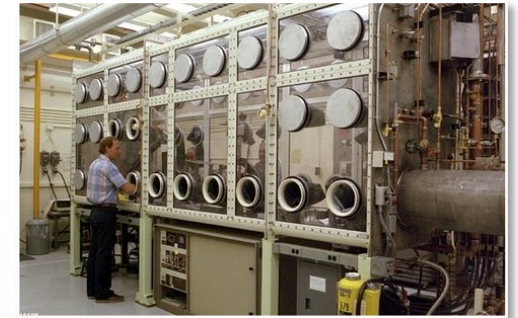
- **DOE fund accelerated FCF treatment rate of EBR-II spent fuel**
 - FCF transitioned from 4x10 operation to 7x12 in April
 - Improved process to reduce radioactive contaminants in product
- **Private sector partners fund**
 - Procurement of glovebox and equipment design, build, testing, and installation
 - INL engineering and quality personnel to be engaged
 - INL preparation of process design and requirements
- **Funding source TBD, INL to execute**
 - Safety design strategy, hazard analysis, safety analysis
 - Preparation of building, including relocating current mission, building mods, HVAC design and installation



*U metal
recovered during
fuel treatment*



HALEU metallic ingots



Inert-atmosphere glovebox



*Arc-melter for
alloy/compound
preparation*

HALEU Fuel Fabrication – Current Estimates

- **Facility Preparation Cost Estimate: \$39M (-10%/+30%)**
 - Facility cleanout: \$2M
 - Facility modifications and operational readiness: \$19M
 - Equipment: \$18M
- **Operations Cost Estimate: \$106M (-10%/+30%)**
 - FCF HALEU production (increment to accelerate EBR-II fuel treatment): \$35M
 - Fuel fabrication: \$71M
- **Schedule:**
 - At 7x12 FCF operation
 - 5 MT HALEU feedstock completed in FCF: Dec. 2023
 - 5 MT fuel fabrication complete: ~ Dec. 2023
 - If FCF accelerated to 7x24 by June 2022, little no improvement
 - Little to no improvement in schedule to 5 MT fuel
 - Would be needed to maintain 1 MT/yr feedstock rate in later years

Open Issues and Concerns for HALEU Fuel Plan

- **DOE decisions are pending and funding availability has been uncertain**
 - Mitigated by
 - Current focus on facility preparation; not mission-specific
 - Initial engineering and contracting supported by available DOE funds
- **Uncertainty in specific designs and fabrication processes to be supported introduce project and schedule risk**
 - Mitigated by
 - Generic approach to fabrication process
 - INL fuel and process expertise anticipating requirements, to some extent
 - Clear communication to private partner regarding risk and uncertainty
- **Private-partner schedule uncertainty**
 - Mitigated by near-term focus on ASAP provision of fabricated fuel
 - Should meet schedule objectives for all inquirers to date, with one exception



Idaho National Laboratory



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