U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

Topic Area 3 – Fuels

Up to 3 years and up to $1,000,000

FL-1: Accident Tolerant Fuels | ***Frank Goldner, Federal POC***

FL-2: TRISO Fuels | ***Matt Hahn, Federal POC***

FL-3: Metallic Fuels | ***Ken Kellar, Federal POC***

FL-4: Other Fuels Topics

Topic Area 3

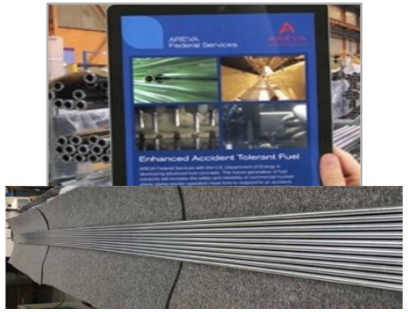
Fuel Cycle Technologies

- Advancements in fuel systems, fabrication processes, cladding concepts, and evaluation techniques are important to continue progress already achieved in increasing improvement of fuel performance.
- NE solicits proposals that focus on LWR or advanced reactor applications that advance:
  - existing fuels concepts,
  - enhancing performance or resilience of existing fuels including accident tolerant fuels, TRISO-particle fuels, metallic fuel, and
  - other relevant concepts.
- NE also plans to support next generation LWR fuel and advanced reactor applications. All aspects of fuel design, testing, and evaluation will be considered.

Topic
Area 3
FL-1

Accident Tolerant Fuels (FL-1)

Framatome
- Cr-coated M5 cladding
- Doped UO_2
- SiC cladding

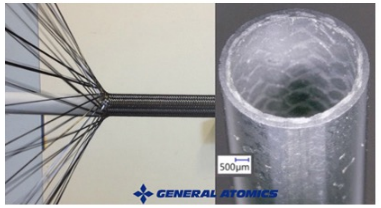


General Electric
- Coated Zr cladding
- Iron-based cladding (FeCrAl)
- ODS variants for improved strength

GE imagination at work

Westinghouse
- Cr-coated Zirlo cladding
- Doped UO_2
- SiC cladding
- Adv. ceramics

General Atomics
- SiC/SiC cladding



Laboratory Activities:

Fuel Specimen fabrication (LANL, INL)
Fuel phase properties (LANL, INL)

Cladding alloy development (ORNL)
Cladding mechanical properties (INL, LANL, ORNL)

Irradiation Testing including loops and separate effects (INL, ORNL, MITR)

Fuel Safety Testing at TREAT (INL)
Furnace testing (ORNL, INL)

Post Irradiation Examination at engineering scale through microstructural (INL, ORNL)

Fuel Performance Analysis and Modeling (INL, LANL, ORNL)

Topic
Area 3
FL-1

Ongoing NE Work Relevant to FL-1

A key NE mission is to support the existing fleet of light water reactors (LWRs) via the Accident Tolerant Fuel (ATF) program. The ATF program activities are meant to enhance the safety and performance of existing LWRs. NE is teaming with the U.S. fuel suppliers to develop accident tolerant fuel concepts in the near term that include coated zirconium cladding and doped UO2 pellets. Longer term concepts include iron-chromium-aluminum cladding, silicon carbide composite cladding, and high uranium density fuels. Proposals are sought in areas that can contribute to enhancing LWR safety and performance.

FY23 Suggested New Technical Areas of Interest	Technical Point of Contact
Accident Tolerant Fuel Impact on LWR Coolant CRUD - Enabled by the coatings utilized in the ATF program, can we do better with LWR coolant chemistry treatments and controls to avoid or minimize the mechanism of CRUD formation and deposition?	David Anderson, LANL
Potential of Accident Tolerant Fuel to Support Power Uprates - Evaluate the impact of accident tolerant fuel (ATF) on the power uprate potential of the existing LWR fleet.	Mike Todosow, BNL
Next Generation LWR Fuels for SMR and Advanced Reactor Applications – How can SMR fuel designs or optimizations benefit from ATF programs current candidates?	Nick Woolstenhulme, INL
Development Of SIC/SIC Composites for Accident Tolerant Fuels for LWRS and Advanced Reactors – Evaluate innovative NDE approaches to understand how SiC/SiC perform in reactor environments	Takaaki Koyanagi, ORNL
Others – Innovations research that would enhance safety and performance of existing LWRs	

Topic
Area 3
FL-1

Areas Not of Interest

- Technologies that are related to thorium fuel cycle
- Technologies that require major changes to existing LWR fuel assembly design and reactor coolant system
- Technologies that are based on liquid fuels
- Technologies that are based on a closed fuel cycle

Topic
Area 3
FL-2

TRISO Fuels (FL-2)

- **Fuel development and qualification**
  - TRISO-particles are a fuel form that has demonstrated robust safety performance for high temperature gas cooled reactor applications
  - Numerous U.S. companies are pursuing the use of TRISO fuel in their advanced high temperature reactor concepts
  - TRISO-fueled reactors often use nuclear grade graphite as moderator and a fuel matrix material consisting of graphite and pyrolyzed resin
- **Potential areas of focus could include, but are not limited to:**
  - Fuel and fuel matrix properties under irradiated conditions
    - Enable more sophisticated fuel models
    - Support industry in qualifying unique fuel designs
  - Novel, non-gas cooled TRISO applications
    - Molten salt or microreactors
  - Novel TRISO fuel forms, including new kernel compositions

Topic
Area 3
FL-2

Ongoing NE Work Relevant to FL-2

- **Industry and DOD applications include, but are not limited to:**
  - X-energy advanced reactor demonstration (Xe-100)
  - Kairos Power risk reduction award (Hermes)
  - BWXT risk reduction award (BANR)
  - BWXT Project Pele
- **AGR-5/6/7 PIE, safety testing**, final reporting, and NRC licensing reports (FY27)
  - Preliminary Capsule 1 analysis indicates particle failures caused by thermocouple issues.[1]
  - Still need critical data to verify performance of fuel fabricated at the pilot-scale
- **Fuel oxidation testing in** air/moisture ingress (AMIX) furnace system
  - Key data gap in demonstration of fuel performance during accidents
  - AMIX system in development; testing to begin in 2023
- **Graphite experiments and studies**
  - Advanced graphite creep (AGC) experiments and PIE, structural graphite
  - Oxidation studies examine oxidation rate, oxidation of irradiated graphite, and post-oxidation material properties

[1] *J. Stempien et al., "Initial Observations from AGR-5/6/7 Capsule 1," INL/RPT-22-66720, April 2022.*

Areas Not of Interest

- Heavy ion irradiation for investigating fuel and fuel matrix properties, without showing equivalence to neutron irradiation, or AGR TRISO results.
- Computer codes that duplicate PARFUME and BISON models, but new modeling enhancements for critical phenomena would be useful.
- Proposals that replicate previous NEUP project results.

Topic
Area 3
FL-3

Metallic Fuels (FL-3)

General Fuel Goals

Manufacturability, economics, safety, resource utilization

Incremental improvements over EBR-II reference fuel

More specifically:

Open Cycle Fuels
• Optimizing fuel life and energy output • Storability, transportability and disposability • Chemically reactive or liquid bonds are to be avoided

Closed Cycle Fuels
• Maximizing fuel burnup and performance • Facilitating reprocessing • Geologic repository burden minimization • Fuel/clad bonding is acceptable

Metallic Fuels Modeling
• First principles • Predictive capability • Design streamlining • Licensing support

Topic
Area 3
FL-3

Ongoing NE Work Relevant to FL-3

- Cladding life extension: getters, liners, conceiving and optimizing cladding materials
- Manufacturing: fuel slug fabrication, co-extrusion, cladding material fabrication, shaping, joining
- Testing without a fast reactor:
  - out-of-pile: separate effects
  - in-pile: shielded, miniaturized, accelerated
  - instrumentation, test vehicles - steady and transient (also see NSUF)
- Models expanding into the advanced reactor fuel realm
- Searches for engineering solutions using an efficient balance of empiricism and modeling

Topic
Area 3
FL-3

Areas Not of Interest

- Technologies that are related to thorium fuel cycle
- Propulsion i.e nuclear rocket motors
- Once-through (open cycle) metal fuels are currently of higher interest than closed cycle due to industry interest, however we want to continue advancing closed cycle fuel concepts
- Uranium enrichments greater than 20%
- Ion beam irradiation is not yet a proven tool although promising (if proposed, address current state-of-the-art and addressing non-prototypic aspects in scope of work)

Topic
Area 3
FL-4

Other FuelsTopics (FL-4)

Proposals that are relevant to fuel cycle technologies as described in the Topic Area 3 overview but are not covered by the previous topic categories can be submitted to FL-4 for consideration.

It is important to note that any submission to this category can be crosscutting, but must reinforce the Office of Nuclear Energy’s mission and the following supporting goals:

“Advance nuclear energy science and technology to meet U.S. energy, environmental, and economic needs.”

1. Enable continued operation of existing U.S. nuclear reactors.
2. Enable deployment of advanced nuclear reactors.
3. Develop advanced nuclear fuel cycles.
4. Maintain U.S. leadership in nuclear energy technology.

Questions?