CHANGING WHAT'S POSSIBLE

ONWARDS—Optimizing Nuclear Waste and Advanced Reactor Disposal Systems

PROJECT DESCRIPTIONS

General Electric (GE) Global Research – Niskayuna, NY

Resonance Absorption Densitometry for Materials Assay Security Safeguards (RADMASS) - $4,499,463

General Electric (GE) Global Research is proposing to develop an innovative active interrogation (nuclear resonance densitometry) technique capable of providing accurate total fissile mass measurements (uncertainty ≤1%) with low latency in a high radiation background. GE's project will demonstrate the Resonance Absorption Densitometry for Materials Assay Security Safeguards (RADMASS) technology using surrogate materials in a non-radiation environment. The GE team will use photonics and nuclear modeling and simulation to show proof of concept for the ability of RADMASS to operate in a high radiation nuclear fuel reprocessing hot cell (radiation containment chamber) facility.

TerraPower – Bellevue, WA

Chloride-Based Volatility for Waste Reduction and/or Reuse of Metallic-, Oxide-, and Salt-Based Reactor Fuels - $8,550,000

TerraPower aims to harness the volatility of chloride salts at high temperatures for use in used nuclear fuel (UNF) disposition, with the potential of some recycling. The goal is to adjust chloride-based volatility (CBV) parameters to achieve a high degree of uranium recovery thereby reducing waste volumes. Work will begin with surrogate UNF and progress to demonstration with actual oxide UNF. TerraPower seeks to demonstrate that the CBV process can be applied to metallic-, oxide- and salt-based reactor fuels and, with prior work demonstrating recovery of better than 99% of uranium from irradiated oxide fuel, it may be possible to reduce repository burdens by a factor of 10-20x.

Citrine Informatics – Redwood City, CA

Novel Phosphate Waste Forms to Enable Efficient Dehalogenation and Immobilization of Salt Waste - $3,103,770

Citrine Informatics proposes to use state-of-the-art artificial intelligence and physics-based simulation methods to rapidly develop novel phosphate waste forms (including glasses, ceramics, and their composites) to enable dehalogenation (removal of halides) and more secure immobilization of salt waste from molten salt reactors. The program will culminate in a kg-scale proof-of-concept of the designed waste form, demonstrating >6x increase in waste mass loading and 80% decrease in waste form volume over existing technologies. The proposed technology will result in 60% decreases in the capital and operating expenditures of waste form processing.

Rutgers University – New Brunswick, NJ

Pioneering a Cermet Waste Form for Disposal of Waste Streams from Advanced Reactors (PACE-FORWARD) – $4,000,007

Rutgers University aims to deliver a simple, scalable route for immobilizing multiple waste streams (metals, salts, carbon) emanating from any potential advanced reactor fuel cycle into a singular, high-density, durable cermet (a heat-resistant ceramic and metallic composite) waste form. The cermet will comprise stainless steel waste as the primary phase, encapsulating a ceramic phase dispersed homogeneously throughout the metal matrix, which will be consolidated to reduce porosity. The proposed technology will (1) substantially minimize processing of waste streams, obviating the need to develop multiple waste forms for separate waste streams; (2) reduce the repository footprint by ≥1 order of magnitude compared with light water reactors; (3) be suitable for multiple disposal environments; and (4) reduce production and operation and maintenance costs by ~50% compared with incumbent technologies.

Rensselaer Polytechnic Institute – Troy, NY

Metal-Halide Perovskites as Innovative and Cost-Effective Fluoride Salt Waste Forms - $607,505

Rensselaer Polytechnic Institute (RPI) will explore inorganic metal halide perovskites (MHPs) as advanced salt waste forms. MHPs are capable of immobilizing a wide range of waste elements in fluoride salt wastes from advanced reactors. The team will also explore the scalability of a low-temperature, wet-chemistry (liquid phase analysis) process in synthesizing large quantity MHPs at low cost. The success of this project will offer a solution for effectively managing complex fluoride salt waste streams critical for the sustainable development of advanced nuclear fuel cycles and advanced nuclear reactor technologies.

Orano Federal Services – Charlotte, NC

Off-Gas Treatment Process for Conditioning and Recycling Facilities - $2,249,573

Orano Federal Services proposes a modular off-gas treatment system designed to treat the off-gases released from different types of advanced reactor used nuclear fuel processing facilities. The system can be set up to treat off-gases from the processing facilities through the combination of two or more modular capture units for ruthenium, tritium, iodine, carbon, noble gas, and particulate. The modular units will satisfy regulatory limits for off-gases and ensure operators can monitor performance of individual units and service them with minimal impact to the upstream processing facilities. Treatment processes will be identified for the wastes produced by each modular unit to ensure the final waste forms will be suitable for either disposal or long-term decay storage.

Brigham Young University – Provo, UT

Two-Step Chloride Volatility Process for Reprocessing Used Nuclear Fuel from Advanced Reactors - $900,217

Brigham Young University seeks to reduce risks and uncertainty of the two-step chloride volatility (TSCV) process by quantifying the volatility of uranium/transuranic (U/TRU) chlorides in simulated used nuclear fuel (UNF) mixtures, optimizing process parameters for U/TRU extraction, and demonstrating TSCV up to a one-kilogram batch size. TSCV provides a solventless separation scheme that reduces waste by co-extracting U and TRU elements from UNF. TSCV eliminates high-level liquid waste from reprocessing UNF in solvents, and recycles hydrogen chloride gas and chlorine gas within the process. The challenge in developing TSCV is limited data on the effect of interactions between salt species on the volatility of U/TRU chlorides within salt mixtures relevant to AR fuels, particularly molten salt reactors.

Idaho National Laboratory – Idaho Falls, ID

Traveling Molten Zone Refining Process Development for Innovative Fuel Cycle Solutions - $2,076,343

Idaho National Laboratory (INL) aims to confirm that the melting and solidifying of used metallic fuel forms three separate, immiscible (incapable of mixing) layers containing actinide, lanthanide, and alkaline earth metals, respectively, as well as a condensate phase containing alkali metals. This expected immiscibility offers an untapped opportunity for innovative fuel cycle solutions. INL aims to develop a thermal treatment process to rapidly extract actinides from used metallic fuels via a traveling molten zone system. The team envisions that one rapid pass of the molten zone from the bottom to the top of the metallic rod incorporating species of used metallic fuels should realize the expected immiscible layer formation and provide species partitioning data effectively and cleanly.

Oklo – Sunnyvale, CA

Enabling the Near-term Commercialization of an Electrorefining Facility to Close the Metal Fuel Cycle - $4,000,000

Oklo aims to commercialize a state-of-the-art nuclear fuel recycling facility within the next few years. The facility will produce fuel for Oklo's metal-fueled reactors, closing the advanced reactor fuel cycle. This project will focus on (1) industrializing and automating key processes of an electrorefining facility used for recycling nuclear fuel and will address each key unit operation and ultimately demonstrate the end-to-end integrated process with simulated fuel, (2) preparing the facility for licensing by the Nuclear Regulatory Commission, and (3) establishing a plan for the ultimate disposal of the resulting waste. This technology is expected to reduce waste by more than an order of magnitude compared with a no-reprocessing baseline.

Stony Brook University – Stony Brook, NY

MATRICY: Matrix Engineered TRISO Compacts Enabling Advanced Reactor Fuel Cycles - $3,400,000

Stony Brook University proposes a comprehensive systems approach to significantly reduce compact reactor waste burden via improved fuel utilization and reduced uranium loading. The root technology is a TRISO-based microencapsulated fuel employing MgO as a low-waste and repository-ready fuel form, which will be engineered to enable deconsolidation of intact TRISO particles and evaluated in parallel as a final waste form for long-term disposition. The team will couple reactor analysis with a program to fabricate and understand the performance of the new fuel and waste forms to realize more than an order of magnitude reduction in nuclear waste metrics compared with state-of-the-art technologies.

Deep Isolation – Berkeley, CA

UPWARDS: Universal Performance Criteria and Canister for Advanced Reactor Waste Form Acceptance in Borehole and Mined Repositories Considering Design Safety - $3,608,399

Deep Isolation seeks to establish a novel universal canister system for advanced reactor waste streams. The new universal canister will create an elemental waste form component that will decouple the interdependent constraints between storage, transport, and disposal. The value proposition of this approach is to minimize the long-run costs of used fuel and waste management by packaging waste forms in small canisters that can be stored in dry storage systems (on site or centrally), transported to a geologic repository, and disposed without repackaging, regardless of how the uncertainties are resolved.