CHANGING WHAT'S POSSIBLE

CURIE—Converting UNF Radioisotopes Into Energy

PROJECT DESCRIPTIONS

GE Research – Niskayuna, NY

Monochromatic Assays Yielding Enhanced Reliability (MAYER) - $6,449,997

GE Research (GE) will develop the Monochromatic Assays Yielding Enhanced Reliability (MAYER) technology, a revolutionary safeguards solution for aqueous nuclear reprocessing facilities. MAYER uses a groundbreaking compact and tunable laser Compton scattering radiation source to provide a monochromatic, high-photon flux beam to enable high accuracy (<1% uncertainty), low latency (<2 minutes), in situ elemental and isotopic concentration measurements of fissile elements in a high radiation background. GE will also build a reprocessing facility safeguards management virtual pilot digital twin that leverages digital ledger technology to ensure data integrity and transparency. The digital twin will enable continuous, on-demand artificial intelligence training to provide an active defense to lower standard errors in materials inventory and predict adverse events, to enable mitigation before a required facility shutdown.

University of Alabama at Birmingham – Birmingham, AL

Group Hexavalent Actinide Separation: A Single-Step, Proliferation-Resistant Approach to Nuclear Fuel Reprocessing - $1,844,998

The University of Alabama at Birmingham (UAB) will develop a single-step technology to recycle used nuclear fuel (UNF) that can recover the bulk of uranium (U) and other transuranics (TRU) as the first step after dissolution in nitric acid. UAB will work toward the recycling of UNF through the co-crystallization of oxidized TRU with uranyl nitrate hexahydrate. This single-step, group actinide separation will (1) significantly reduce the volume of light-water reactor high-level radioactive waste that requires permanent disposal, (2) provide an appropriate fuel feedstock by combining U/TRU in a single product stream, (3) reduce fission product content in the product stream to <0.1%, and (4) provide compatibility with online monitoring technologies.

NuVision Engineering – Mooresville, NC

Modular Power Fluidics and Online Optical Spectroscopy for Reprocessing Plant Control and Accountancy - $4,715,163

NuVision Engineering will design, build, commission, and operate an integrated material accountancy test platform that will target the prediction of post-process nuclear material accountancy to within 1% uncertainty for an aqueous reprocessing plant. The accountancy platform will be fabricated as a modular unit with power fluidics (PF) and online optical spectroscopy (OOS) systems integrated into the vessel intended to last the lifetime of an aqueous reprocessing plant. The PF suite has no moving parts and includes devices to mix, sample, and pump highly radioactive fluids to provide real-time liquid level and density data. The OOS system facilitates a transition from near-real- to real-time monitoring of uranium and plutonium concentrations.

University of North Texas – Denton, TX

Self-Powered Wireless Hybrid Density-Level Sensing with Differential Pressure Sensors for Safeguarding and Monitoring of Electrochemical Processing of Nuclear Spent Fuel - $2,711,342

The University of North Texas (UNT) will develop a novel self-powered wireless differential pressure sensor for long-term, in situ, real-time monitoring of high-temperature molten salt density and level for safeguarding and monitoring electrochemical processing of used nuclear fuel. The UNT team will design and fabricate the pressure sensor using micro-electromechanical systems technology which enables measurements of great sensitivity, accuracy and high repeatability. To provide unlimited power for the sensor and wireless transceiver, a thermoelectric generator will be directly printed on the electrorefiner housing.

Argonne National Laboratory – Lemont, IL

Radioisotope Capture Intensification Using Rotating Packed Bed Contactors – $1,520,000

Argonne National Laboratory will develop, produce, and test a suite of compact rotating packed bed contactors (RPBs) referred to as PAcked Centrifugal Equipment for Radiochemical separations (PACERs) for used nuclear fuel reprocessing. The PACERs technology consists of a cylindrical rotating bed of packing (e.g., glass beads) through which liquid is expelled via an applied centrifugal field. This increases the efficiency of separations in packed beds and decreases the required packing volumes more than 50% compared with state-of-the-art columns. PACERs could replace current CO_2 and I_2 off-gas scrubbing systems, pulsed columns, and ion exchange columns used for traditional gas-liquid, liquid-liquid, and solid-liquid separations, respectively. These units will also have lower installed costs than packed columns because of decreased material, manufacturing, and shielding requirements.

University of Colorado, Boulder – Boulder, CO

Achieving 1 % Assay of Special Nuclear Materials in 2 Minutes with Microcalorimeter-Array Gamma-Ray Spectroscopy - $1,994,663

The University of Colorado, Boulder (CU-Boulder), will advance high resolution gamma-ray spectroscopy using cryogenic microcalorimeter arrays, which are an emerging tool for improved nuclear material accountancy. Microcalorimeters are currently capable of reaching the CURIE program's 1% uncertainty target but fall far short of its speed goal. CU-Boulder will produce individual microcalorimeter pixels that can achieve 200 counts per second count rates (20x faster than current devices), which will allow a system with 4,000 such detectors to make the required 1% measurement of plutonium isotopic content in 2 minutes. This capability can determine uranium (U) enrichment in high-assay low-enriched uranium, fissile material content throughout reprocessing and waste streams, high-accuracy plutonium (Pu) isotopic assays, and potentially key U/Pu isotope ratios in uranium/transuranic (U/TRU) products.

University of Utah – Salt Lake City, UT

Pyrochemical Dissolution of LWR Spent Fuel with Actinide Recovery for Advanced Reactors - $1,454,074

The University of Utah will develop a pyrochemical process for efficiently converting used nuclear fuel (UNF) to a uranium/transuranic (U/TRU) product suitable for sodium-cooled fast reactors or molten-salt fueled reactors. This process is based on two key separations steps that can occur in a single reaction vessel: (1) dissolution of oxide UNF in molten lithium chloride (LiCl)-potassium chloride (KCl) salt and (2) electrochemical recovery of U/TRU metal on a cathode. If successful, this will be the first pyrochemical process to feature an input accountability tank to support rigorous safeguards. Overall, this technology should result in less material handling and lower space requirements than conventional pyroprocessing technology via elimination of fuel baskets, consolidation of processing units, and use of a single solvent salt (i.e., LiCl-KCl), and it could also open a pathway for high-throughput, economical pyrochemical processing of UNF.

Curio – Washington, DC

Closing the Cycle with NuCycle™ - $5,000,000

Curio™ will develop and demonstrate its used nuclear fuel (UNF) recycling process, NuCycle™, at the laboratory scale. NuCycle has been intentionally designed to avoid production of pure plutonium streams and dramatically reduces waste volumes over existing processes. Several commercial products are envisioned from the process, including uranium/transuranic fuel and valuable radionuclides. Designed for facility footprint reductions with substantial economic efficiency, NuCycle uniquely leverages well-understood chemical processes and can accommodate a variety of UNF types (e.g., molten salts, nitride fuels, etc.). NuCycle shifts the current paradigm on "nuclear waste" by recasting it as an asset and creates the commercial case for UNF recycling in the U.S.

Argonne National Laboratory – Lemont, IL

Highly Efficient Electrochemical Oxide Reduction for U/TRU Recovery from LWR Fuel - $4,900,000

Argonne National Laboratory (Argonne) will develop an electrochemical oxide reduction (OR) process that meets the CURIE program's cost and waste metrics for a commercial pyroprocessing facility. Electrochemical OR is a single-step process that converts used oxide fuels to metal, but current inefficiencies result in non-uniform and incomplete conversion to metal, long process times, and large waste volumes. Argonne will demonstrate a highly efficient OR process with 97% conversion of the oxide fuel to metal by (1) incorporating sensors to monitor oxide-to-metal conversion, (2) using stable and efficient next-generation anode materials, and (3) optimizing cell designs to achieve spatially uniform conversion to metal.

Idaho National Laboratory – Idaho Falls, ID

Development of Robust Anode Materials for the Electrochemical Recovery of Actinide Elements from Used Nuclear Fuel - $2,659,677

Idaho National Laboratory (INL) will design, fabricate, and test robust anode materials for electrochemically reducing actinide- and fission product- oxides in used nuclear fuel (UNF). Electrochemical reduction of UNF is a key step in pyroprocessing flowsheets that enables subsequent recovery of actinides via electrorefining. Current anodes, which are typically fabricated from either platinum or graphite, suffer from high cost, rapid degradation of anode materials, contamination of the metallic product, and negative impact on carbon footprint. To reduce anode costs and improve performance, INL will fabricate and evaluate the performance of coated and bimetallic anodes of iridium and ruthenium for commercial use. Developing robust anode materials supports a transformative solution to treating oxide UNF without generating greenhouse gases or isolating pure plutonium.

EPRI – Charlotte, NC

Establishing an Advanced Reactor Fuel Cycle Enterprise - $2,796,545

EPRI will develop an integrated fuel cycle enterprise, intended to address the coupled challenges of nuclear fuel life-cycle management and advanced reactor fuel supply. Input light water reactor fuel source options will be characterized and evaluated for economic viability, along with options for a recycling facility that produces fuel for advanced reactors, such as a molten chloride fast reactor (MCFR). EPRI will use this information to develop a recycling facility optimization tool to evaluate the many viable process options for their compatibility and efficiency. The output will inform the design of a recycling facility collocated with multiple fuel cycle facilities, potentially on an operating light-water reactor site.

Mainstream Engineering – Rockledge, FL

Improved Volatile and Semi-volatile Radionuclide Off-Gas Management - $1,580,774

Mainstream Engineering will develop a series of vacuum swing separation unit operations to separate and capture volatile radionuclides. Capturing and storing volatile radionuclides from the off-gassing of used nuclear fuel aqueous reprocessing facility operations represents more than 10% of current capital costs and a significant fraction of operating costs. The vacuum swing adsorption units will contain targeted, specific adsorbents for the removal and concentration of the radionuclides to maximize the efficiency of the overall process to drive the life cycle capital and operating costs down and minimize waste that must be stored. These compact units will also reduce the amount of shielded area required, simplify off-gas logistics, and reduce energy needs while they ensure the capture of more than 99.9% of volatile radionuclides.