Flibe Energy
partnered with
Oak Ridge National Laboratory

NE-19-18380, Liquid Fluoride Thorium Reactor (LFTR) Preliminary Safeguards Assessment

YEAR AWARDED: 2019

TOTAL PROJECT VALUE: $500k (DOE: $400k; Flibe Energy: $100k)
STATUS: Completed

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DESCRIPTION: Flibe Energy, Inc. (FEI) is developing the Lithium-Fluoride Thorium Reactor (LFTR), an innovative two-fluid molten-salt reactor (MSR) design operating on a thorium/233U fuel cycle. FEI intends for LFTR to become a self-sustaining clean energy source that can create or breed its own fuel from thorium. Each LFTR is intended to breed enough fissile material to compensate for the amount it consumes. Consequently, it would not require fissile replenishment during its operational lifetime, eliminating the need for uranium enrichment infrastructure after the first generation. LFTR would also utilize internal chemical processing to purify its fuel salt and remove fission products. At the end of its operation, the salts are to be recycled to the next generation of LFTRs. This would nearly eliminate the production of long-lived radioactive wastes and retain all actinides in useful operation in a steady-state environment.

CHALLENGES: The LFTR MSR design presents challenges for domestic safeguards as defined by the U.S. Nuclear Regulatory Commission (NRC) as well as international safeguards as applied by the International Atomic Energy Agency (IAEA). The Th/233U fuel cycle is fundamental to LFTRs. One key design feature of LFTRs is the production of nearly pure 233U from its short-lived precursor 233Pa (half-life ~27 days), which is produced from the neutron capture of thorium and subsequently held in a decay tank before the fluorination process step. While 233U is central to the operation of LFTR, separated 233U presents a target for theft and diversion. Furthermore, the production of 233U within the decay tank results in the production or accumulation of fissile material outside the reactor vessel. Other challenging aspects of this design include the continuous online processing of the nuclear material in addition to the continuous chemical processing of the blanket and decay salts. This continuous processing, in addition to the changing nuclear material isotopic composition in the fluid salts, poses challenges for measuring and identifying what nuclear material is present and where it is present in the reactor and processing systems.

IMPACT: The purpose of this GAIN voucher research is to provide FEI with design recommendations for the implementation of nuclear material accountancy and enable FEI to meet its sustainability and operational goals for the LFTR.

SIGNIFICANT CONCLUSIONS: The significant outcomes of this work were several preliminary design recommendations for the process flow sheet and LFTR chemical processing system within the 2018 LFTR design, which led to the generation of a revised 2021 LFTR design by FEI, improved nuclear material accountancy, and potentially improve the future safeguardability of LFTR.

NEXT STEPS: FEI has reached out to the NA-241 Advanced Reactor International Safeguards Engagement (ARISE) Program for continuing DOE assistance on international safeguards. ORNL and LANL are developing a proposed continuing scope of work for international safeguards under the ARISE Program FY23 Call for Proposals, which would build on the results of this GAIN voucher and be developed in consultation with FEI. Proposed next steps include evaluating the design recommendations from this GAIN voucher for their impact on international safeguards and investigating relative tradeoffs for domestic safeguards and security.