



Design and License Application Development for TRISO-X: A Cross-Cutting, High Assay Low Enriched Uranium Fuel Fabrication Facility

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Program: First of a Kind Nuclear Demonstration Readiness

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Objectives of the Project:

Advanced nuclear reactors with high margins of safety and modular increments of power expansion are the future of nuclear power. The most critical element in the design of these reactors is a robust fuel that can withstand very high temperatures without melting, while providing greater efficiency than what is currently achieved in the existing light water reactor (LWR) fleet. Given that all these reactors require fuel that is enriched to greater than 5% Uranium-235, Nuclear Regulatory Commission (NRC) licensing is a critical element of the process that the Advanced Reactor (AR) community must address now to have a credible reactor deployment program by the mid-2020s. This Project proposes the design and license application development for a facility—the TRISO-X Facility—capable of handling the high assay low enriched uranium (HALEU, 5%²³⁵U<20%) and production of U.S. developed uranium oxycarbide (UCO) TRistructural ISotropic (TRISO) particle based fuel elements required for the coming fleet of ARs.

Description of the Project:

The proposed Project has four main tasks: **1)** conduct studies to assess fuel design and utility/operator requirements for all ARs, **2)** using these studies as key inputs, complete the preliminary and final designs of the TRISO-X Facility, **3)** complete the license application for this facility, and **4)** complete the licensing application process with the NRC and obtain acceptance and docketing of the application submittal. We expand on these four primary tasks below:

- 1. Feasibility Studies:** Perform three feasibility studies, including (a) reactor fuel element requirements analysis; (b) utility/operator fuel requirements analysis, and (c) concept design of the second-most likely fuel form process module (in addition to pebbles). The information in these studies informs the layout of the TRISO-X Facility production modules and the scope of CAT II license application.
 - 2. Fuel Fabrication Facility Preliminary and Final Design Development:** Continue our design activities for developing the TRISO-X Facility that supports the fabrication of TRISO-based fuel elements to enable the first core and refueling requirements of U.S. ARs. We completed conceptual design of a pebble specific facility in March 2017; once we receive funding we can complete the Preliminary Design and Final Design of our CAT II facility, which can service all ARs. The facility focuses first on common kernel and TRISO production to support pebble fuel forms; we include space for the modular expansion of production equipment for additional fuel element forms.
 - 3. NRC Fuel Facility License Application Development:** Develop our NRC license application, including conducting siting alternatives analysis, developing the Safety Program Description (SPD), Environmental Report (ER), Security Plan (SP), and Emergency Plan (EPlan), as well as proactively engaging and working with the NRC prior to the post-submittal review process.
 - 4. NRC Review and Interaction:** Continue formal dialogue with the NRC following submission of the license application to ensure our application is accepted and docketed.
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List of Major Deliverables:

- NRC CAT II Fuel License Application
- Preliminary Design Review Package
- Final Design Review Package
- Feasibility Studies on reactor fuel element requirements, utility/operator analysis, and Conceptual Design of 2nd process module for deployment

We ensure completion of the tasks and submittal of the major deliverables by arranging the work scope into a clearly defined work breakdown structure (WBS) with five elements: Project Management, Systems Engineering, TRISO-X Facility Design, Facility License Application Development, and Support to Application Review. Our WBS outlines roles and responsibilities by X-energy team member and aligns to a detailed schedule with logic ties to activities between WBS or tasks. Development of the WBS follows the logic path X-energy uses on our successful Advanced Reactor Concept (ARC15) cooperative agreement, where we integrate overall project management with discrete WBS tasks, each with specific subtasks. Each *TRISO-X Facility Design and License Application Development* WBS is led by an exemplary team with the necessary highly specialized and unique experiences in nuclear facility design, fuel manufacturing processes, and licensing to successfully carry out this Project.

Potential Impact of the Project:

Deployment of ARs in the mid-to-late-2020s, a stated Goal of the DOE, ties directly to the viability of a fabrication facility capable of fueling these reactors. The design and license application completion for the TRISO-X Facility proposed here has significant positive impacts for U.S. manufacturing and nuclear energy, including:

- *Increased competitiveness of the U.S. nuclear industry:* The Chinese have completed a commercial AR UO₂ TRISO fuel facility and AR power plant (HTR-PM); the TRISO-X Facility Project enables near-term competitiveness by employing a superior fuel (UCO TRISO) manufactured in a U.S. fuel fabrication facility (the TRISO-X Facility), as well as supporting the overall deployment of several AR designs
- *Improved capabilities of the existing fleet:* UCO TRISO particles offer future potential, with additional research, to enable improvements to LWRs using TRISO-based accident tolerant fuels (ATFs)
- *Improved timelines for AR deployment:* Without a stable source of U.S. HALEU and a licensed CAT II fuel fabrication facility, the deployment timeline for ARs will always be measured in decades. This Project and team can improve (i.e., reduce) the timeline for deployment through the design and license application development for the TRISO-X Facility.
- *Improved cost and schedule for AR deployment:* UCO TRISO technology offers higher burn-ups and improved safety at high temperatures; this competitive advantage enables U.S. ARs to out-perform and be more economical as compared to foreign UO₂-based ARs.
- *Design and engineering process development:* This Project focuses on the design of a CAT II fuel fabrication facility, a first in the U.S., with engineering processes capable of producing HALEU and TRISO-based fuels
- *Resolution of regulatory issues:* This Project enables early engagement, during pre-application development, with the NRC to understand and resolve any open issues regarding CAT II facility licensing, which enables other domestic suppliers by establishing a well-documented, expedited path to future CAT II facility licensing for both reactor and fuel complexes.

Major Participants:

The Team is comprised of X-energy (Prime Applicant) and partners Centrus Energy, Oak Ridge National Laboratory (ORNL), Sargent and Lundy, and Southern Nuclear Development (SND)
