DOE-ID NEPA CX DETERMINATION

CX Posting No.: DOE-ID-21-121

SECTION A. Project Title: Continuation of Work for the Accident Tolerant Fuel Project 2021-2025

SECTION B. Project Description:

Westinghouse Electric Company LLC proposes the continuation of the Westinghouse Accident Tolerant Fuel (ATF) program from February 1, 2021, to January 31, 2025, to support the further development of Westinghouse's ATF Fuel design, EnCore®1 fuel now includes high burnup - higher enrichment fuel (HBHE). The Westinghouse program goals are:

1. Continue licensing and manufacturing interactions aimed at implementation of regions of Cr coated zirconium cladding (AXIOM™ and Optimized ZIRLO™) with Advanced Doped Pellet Technology (ADOPT™) fuel pellets by mid-2020s;
2. Address licensing data needs for extending burnup of ADOPT fuel pellets and UO_2 in Cr coated Zr cladding to 75 megawatt days per kg U (MWd/kgU) via high burnup/higher enrichment fuel, HBHE;
3. Demonstrate a full length SiGA® SiC rod in a pressurized water reactor (PWR) water filled tube by 2023 to support licensing and manufacturing interactions aimed at implementation of regions of SiC clad fuel in 2030;
4. Continue development of a corrosion resistant Uranium-Nitride (UN) fuel suitable for deployment in Cr coated zirconium alloy clad PWR lead test rods (LTRs) by 2024;
5. Initial implementation of atomic scale modeling for property evaluation for topical reports and testing and use of in-rod sensors in LTRs to produce data in real time to validate the atomic scale modeling predictions.

The Department of Energy (DOE) objectives for the upcoming 4-year program are:

1. DOE Objective 1: Continuation of current ATF efforts for fuel reloads in Nuclear Reactors with up to 68 MWd/kgU burnup
2. DOE Objective 2: Continuation of high burnup (75 MWd/kgU) - higher enrichment research and testing
3. DOE Objective 3: Pursuit of non-coated cladding concepts already under development (that is SiC)

The tasks proposed to meet the Westinghouse goals are matched with the major Department of Energy (DOE) objectives below:

DOE Objective 1: Continuation of current ATF efforts for fuel reloads in Nuclear Reactors with Up to 68 MWd/kgU burnup
Baseline lead test assemblies (LTAs) will be used to verify the performance of Cr-coated cladding with ADOPT fuel pellets to support the deployment of regions in mid-2020's. The proposed LTAs of EnCore fuel will provide data for the Coated Cladding and ADOPT fuel pellet topical reports for comparison with the performance of the baseline fuel products, and to provide data for licensing review and approval by the Nuclear Regulatory Commission (NRC). Post Irradiation Examinations (PIE) will continue followed by Transient Reactor Test (TREAT) testing and ramp testing in the Advanced Test Reactor (ATR). Engineering review and planning tasks that support the industrial implementation of EnCore fuel will also continue. Qualification of in-rod wireless sensors for fission gas pressure/centerline temperature/fuel swelling to validate atomic scale modeling predictions are being pursued without using LTRs in commercial reactors.

DOE Objective 2: Continuation of high burnup (75 MWd/kgU) - higher enrichment research and testing
PIEs, TREAT testing, and ramp testing of LTRs from Phase 2B and LTAs from Phase 2C activities will continue in order to provide data for topicals supporting burnup extension to 75 MWd/kgU. The PIEs and testing will include both coated and uncoated Optimized ZIRLO and AXIOM fuel pellets to provide a comparison of the performance benefits that can be expected from applying the Cr coating. Westinghouse will initiate discussions with U.S. utilities to determine which reactors will be selected for our LTR/LTA program for HBHE. Work will continue in 2021 and 2022 on engineering, analysis and hardware preparation for an LTA Final Design Review in 2022 and targeted LTA Insertion in 2023/2024. Codes and methods report revisions and submittals to the NRC beginning as soon as 2022, and then there will be interactions and requests for information with the NRC over the next two years to support implementation of region quantities targeted for 2024 to 2026. Interactions with the NRC will continue to complete and update topicals for ADOPT fuel pellets and Cr-coated cladding. Engineering review and planning tasks that support the industrial implementation of >5% enriched ^{235}U EnCore fuel will also continue.

$U^{15}N$ with 5% enriched has a ^{235}U content equivalent to ~6.9% enriched UO_2 and a higher thermal conductivity that also aids in reducing or eliminating fuel fragmentation, relocation and dispersal (FFRD), which is one challenge to licensing fuel burnup to the higher levels required by the shift to 24-month cycles. To enable $U^{15}N$ deployment, ^{15}N enriched N_2 must be produced on an economic commercial scale and corrosion improved $U^{15}N$ must be developed. Processes to produce enriched ^{15}N have been surveyed and preliminary costs obtained as part of the current program. Additional work in this area will concentrate on development of more efficient production techniques for UN and on making the UN more corrosion resistant.
Specific tasks include solving two key challenges for light water reactors (LWRs):

1. Determine successful approach for oxidation resistance;
2. Define scalable production method for UN fabrication.

DOE Objective 3: Pursuit of non-coated cladding concepts already under development
To support SiC deployment, General Atomics (GA) needs to develop a scalable leak test protocol to support future insertions in test and commercial reactors that can be run on-site, must fully understand the factors that affect the performance of and products from the chemical vapor infiltration and deposition processes that are key parts of manufacturing SiC rods, and apply this understanding to startup of a full-length SiC cladding production machine and achieve targeted manufacturing costs.

SECTION C. Environmental Aspects / Potential Sources of Impact

The Westinghouse ATF program goals include the design, licensing and manufacture of Lead Test Assemblies for reactors and continue work on UO_2 and UO_2 with low levels of Cr_2O_3 and Al_2O_3 additives and UO_2 at ^{235}U enrichments up to ~8%, UN fuels and Cr coated Zr and uncoated SiC cladding utilizing a Sn pellet-cladding gap bonding. Oxidation resistant UN is the backup fuel option to UO_2 with >5% ^{235}U enrichment. SiC composite cladding from General Atomics consists of Hi-Nicalon-S SiC fibers infiltrated with SiC using chemical vapor infiltration (CVI) and an outer, hermetic layer of SiC deposited using chemical vapor deposition (CVD). Major organizations participating with Westinghouse Electric Company LLC on this project include:

• Westinghouse Electric Company LLC - Program management, fuel rod and assembly design, testing, business development and future planning (no significant emissions or uses of uranium or chemicals); LTA manufacture, mechanical testing of Cr coated rods, thermal-hydraulic and vibration testing at our Columbia, SC facility; evaluation of samples from the MIT reactor at the Churchill, PA facility; high temperature corrosion, autoclave corrosion, and heat transfer testing at the Churchill, PA facility (no significant emissions or uses of uranium or chemicals); UN corrosion studies at the Churchill, PA facilities; Cr coating of Zr rods at our Churchill facility; polishing of coated tubes (as part of current Zr tube production) at the tube mill in Blairsville, PA (no significant emissions or uses of uranium or chemicals).
• Massachusetts Institute of Technology - In-reactor testing of SiC and Cr coated Zr cladding.
• General Atomics - SiC cladding development and production and test rodlet assembly.
• Idaho National Laboratory – Receipt of lead test rods from commercial reactors and fabrication of rodlets from these rods for ramp testing in the Advanced Test Reactor (ATR) and transient test reactor (TREAT) irradiations and post-irradiation examinations (PIEs) of fuel samples.
• Los Alamos National Laboratory – Studies on UN production, characterization and oxidation resistance and characterization of Cr_2O_3 and Al_2O_3 doped UO_2. Atomic modeling of UN.
• University of Wisconsin – Research on Cr coated Zr rods and critical heat flux testing on long Cr coated Zr rods (no significant emissions or uses of uranium or chemicals).
• Oak Ridge National Laboratory – SiC development, grid to rod abrasion (no significant emissions or uses of uranium or chemicals), HFIR irradiation of SiC CMCs and PIEs and in-rod sensors. Burst testing of hydrided irradiated and unirradiated Cr coated and uncoated cladding (no significant emissions or uses of uranium or chemicals).
• University of South Carolina – SiC and coated cladding thermal-hydraulic studies using recirculating water loops (no significant emissions or uses of uranium or chemicals) and mechanical testing of Cr coated Zr rods. Atomic scale modeling of UN pellets as a function of burnup.
• University of Virginia – Cr coated Zr rods mechanical behavior (no significant emissions or uses of uranium or chemicals).
• Bristol University (UK) – studies of crack propagation phenomena with tests run at the cyclotron at University of California Berkeley (no significant emissions or uses of uranium or chemicals).
• University of Bangor (UK) – atomic scale modeling of UN pellets and properties as a function of burnup.
• Exelon - Customer for ATF LTRs, licensing, design reviews (no significant emissions or uses of uranium or chemicals)
• Fauske & Associates – Accident modeling (no significant emissions or uses of uranium or chemicals)

Radioactive Material Use and Waste Generation

Los Alamos National Laboratory (LANL- manufacture of UN, UN properties, UO_2 with additive properties), Westinghouse Columbia (assembly of reactor components, and Westinghouse Churchill (oxidation testing of UN) will handle the radioactive material under approved Integrated Work Documents which document the relevant procedures, handling limits, safety procedures and disposal routes. They are only handling fresh fuel material. For all non-irradiated fuels, clean uranium containing materials originating from rejected samples (mainly pellets) are crushed and re-used in manufacturing new pellets. Uranium containing other solids materials (dirt) is disposed of by each institution using well established procedures consistent with their license. The amounts of uranium involved are hard to estimate but are all likely to be

<5,000 grams at each institution except Columbia which as an established fuel manufacturer handles multiple tons of enriched material.

Westinghouse Churchill will handle small quantities (<500 grams) of fuel pellets which will result in small quantities of other chemicals (mainly neutralized and evaporated nitric acid) which are employed for processing and cleaning samples. All operations will be performed under authorized work procedures in authorized facilities. Waste profiles exist for disposal of all materials.

INL - The primary mission of the Idaho National Laboratory (INL) is to perform Nuclear Energy research and development. INL has over 40 years of experience in the handling of radioactive materials and has extensive facilities, procedures and trained personnel in place for handling significant quantities of all types of radioactive materials. Under the current proposal, INL's primary role includes receipt of spent fuel rods from commercial reactors for characterization and fabrication of rodlets for irradiation testing in the on-site ATR and Transient Reactor Test Facility (TREAT) reactors. Rods receipted by INL will become DOE-owned. Uranium containing solid materials (dirt) is disposed of by DOE along with other DOE-owned materials.

Subsequent post-irradiation examination (PIE) at INL facilities. The irradiated pellets and PIE samples will remain DOE property and will ultimately be disposed of by DOE along with other DOE-owned irradiated materials and samples.

General Atomics (GA) – GA will assemble test rods for irradiation in INL's Advanced Test Reactor (ATR), with subsequent post-irradiation examination (PIE) at INL. In addition, GA will assemble rods for testing in a commercial reactor. Pool-side examinations and PIEs at INL will then be carried out.

Cladding and in-rod wireless transmitter samples will be irradiated at the Massachusetts Institute of Technology Reactor and Oak Ridge National Laboratory’s (ORNL’s) High Flux Isotope Reactor (HFIR) along with other samples from academia and industry. After irradiation, the samples will be disposed of under their license. Incidental materials will be disposed of using their existing contaminated waste procedures. Their reactors already discharge spent nuclear fuel which is disposed of using their current license. Irradiated cladding samples will be studied at the Westinghouse Churchill facilities and at ORNL. All wastes will be disposed of as part of the ongoing radioactive hot cell waste disposal activities under the current Westinghouse and ORNL licenses.

Chemical Use/Storage, Chemical Waste Disposal, Hazardous Waste Generation, and Industrial Waste Generation

The chemical vapor infiltration (CVI) operation will be performed at a subcontractor (General Atomics) site that does internal R&D using CVI services. Off-gases are scrubbed as part of the process, neutralized and discharged as industrial waste.

University of Wisconsin (UW) and LANL will generate wastes from their coating, testing and manufacturing processes. The non-uranium wastes are non-hazardous and will be disposed of using their accepted disposal processes. LANL’s uranium wastes will be recycled internal to LANL

The waste stream from Cr coating activities at Westinghouse Churchill and UW consists of Cr powder from overspray. Quantities will be less than 500 kg and will be disposed of as solid industrial waste under the current Westinghouse and UW environmental licenses. Gaseous emissions from the Westinghouse Churchill, LANL and University of Wisconsin consist of Ar, N_2 and He and are released to the atmosphere after scrubbing and filtration. Quantity is unknown.

Water/Well Use and Discharge of Wastewater

All steps will require some water use for cooling, cleaning samples, and cleanup. No extraordinary water use is expected above current levels. There are discharges from all facilities, but these are made through established waste treatment facilities at each of the locations.

SECTION D.	**Determine the Level of Environmental Review (or Documentation) and Reference(s):** Identify the applicable categorical exclusion from 10 CFR 1021, Appendix B, give the appropriate justification, and the approval date.

Note: For Categorical Exclusions (CXs) the proposed action must not: 1) threaten a violation of applicable statutory, regulatory, or permit requirements for environmental, safety, and health, including requirements of DOE orders; 2) require siting and construction or major expansion of waste storage, disposal, recovery, or treatment facilities; 3) disturb hazardous substances, pollutants, contaminants, or CERCLA-excluded petroleum and natural gas products that pre-exist in the environment such that there would be uncontrolled or unpermitted releases; 4) adversely affect environmentally sensitive resources. In addition, no extraordinary circumstances related to the proposal exist which would affect the significance of the action, and the action is not “connected” nor “related” (40 CFR 1508.25(a)(1) and (2), respectively) to other actions with potentially or cumulatively significant impacts.

References: B3.6 Siting, construction, modification, operation, and decommissioning of facilities for small-scale research and development projects; conventional laboratory operations (such as preparation of chemical standards and sample analysis); and small-scale pilot projects (generally less than 2 years) frequently conducted to verify a concept before demonstration actions, provided that construction or modification would be within or contiguous to a previously disturbed or developed area (where active utilities and currently used roads are readily accessible). For purposes of this category, “demonstration actions” means actions that are undertaken at a scale to show whether a technology would be viable on a larger scale and suitable for commercial deployment. Demonstration actions frequently follow research and development and pilot projects that are directed at establishing proof of concept.

Justification: The activity consists of deploying additional lead test rods (LTRs) and lead test assemblies (LTAs), harvesting pellet and cladding data from currently available and new LTRs, utilizing samples from these LTRs for ramp, reactivity insertion accident (RIA) and loss of coolant accident (LOCA) testing, and utilizing the resulting data in models used for design and licensing as well as supporting new and existing NRC topical submittals.

Is the project funded by the American Recovery and Reinvestment Act of 2009 (Recovery Act) ☐ Yes ☒ No

Approved by Jason Anderson, DOE-ID NEPA Compliance Officer, on 09/29/2021.