Fuel Cycle & Infrastructure (FC&I) Subcommittee Report

Presentation to the

Nuclear Energy Advisory Committee

Washington, D.C.

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Ralph Disibio (Co-Chair)

Subcommittee Members (* = NEAC Member)

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- Michael Corradini
- Chris Kouts
- Sean McGarvey*
- Ronald P. Omberg
- Carl Paperiello*
- Joy L. Rempe*
- John Stevens
- Dominique Warin
- Alfred P. Sattelberger (Chair)*
- Ralph Disibio (Co-Chair)*

FC&I Subcommittee

- Day and a half meeting on January 24-25
- Presentations covered:
  - Updates/overviews from Acting NE-1 and NE-4
  - Budget and Congressional Updates
  - Experimental and Testing Facilities
  - Accident Tolerant Fuels (ATF) Program, plus EPRI and Vendor Presentations
  - Versatile Test Reactor (VTR)
  - Fast Reactor Metallic Fuels
  - ZIRCEX
  - NE University Programs and User Facilities

Remarks from Acting NE-1

- Stressed the importance of revitalizing the U.S. nuclear fuel cycle (FC) and specific FC-related efforts, including:
  - Versatile Test Reactor (VTR)
  - the ZIRCEX demonstration
  - used EBR-II fuel processing for High Assay Low Enriched Uranium (HALEU)
  - the HALEU enrichment demonstration
  - advanced fuels/Accident Tolerant Fuels (ATF)
  - Transformational Challenge Reactor (TCR)
- NE is also working to open up the advanced reactor pipeline
  - micro-reactors
  - small modular reactors (SMRs)
  - large non-light water reactors

General NE-4 Overview

- Reorganization of NE and NE-4
  - NE-42 – Office of Advanced Fuels Technologies
  - NE-43 – Office of Materials and Chemical Technologies
  - Former NE-41 – Office of Advanced Reactor Technologies, moved to NE-5
- The HALEU cascade demonstration project
- The ZIRCEX program (direct chlorination of used nuclear fuel to remove Zircaloy cladding)
- Versatile Test Reactor (VTR) (TOP PRIORITY)

Budget and Congressional Highlights

- The NE-4 FY19 budget was reviewed, including the breakout funding by Campaign
- Subcommittee is very concerned about NEUP cuts and the impact in FY20 and beyond
- VTR was funded at $65M in FY19 (Reflective of top priority status).
- NE budget was the largest ever appropriated to the program - $1.3 billion
- The Nuclear Energy Innovation Capabilities Act (NEICA) was signed into law by the President on September 28, 2018 (see full report has details)
- In addition to VTR direction, NEICA authorizes DOE:
  - to partner with industry to create a cost-sharing program to help defray the cost of reactor licensing
  - directs DOE to expand high-performance computer capability focusing on advanced reactor modeling & simulation capability
  - establishes the National Reactor Innovation Center.

Experimental and Testing Facilities Update

- The loss of the Halden Boiling Water Reactor (HBWR) in Norway poses a significant challenge to the global nuclear industry, including the ATF program under NE-4 purview
- It is imperative that additional pressurized water loop irradiation capacity be developed for test reactors
- Recommendations:
  - The Subcommittee strongly recommends that a new pressurized water loop be developed for use at the ATR
  - The Subcommittee also strongly recommends that the loop and standardized test rig be developed as a collaboration of experts, including IFE staff from Halden
  - The Subcommittee recommends that the ATF program establish limited redundant capabilities for irradiated fuel re-fabrication and re-instrumentation into test rodlets at PNNL or ORNL
  - The Subcommittee is concerned that a new test loop and standardized test rig to address the Halden 'gap' will be particularly difficult from a human and financial resources perspective

ATF Program Update and Vendor Presentations

- The Subcommittee appreciates the coordination of many presentations at the current review by NE-42, EPRI, NEI, and industry participants: GE, Framatome, and Westinghouse
- The vendors presented proprietary, business-sensitive, updates of their plans to execute a two-phase approach to ATF success under the new Cooperative Agreements with the DOE that were established in 2018
- Each vendor and the DOE NE ATF Program highlighted increased interaction with the NRC
- Recommendations:
  - The Subcommittee recommends that the engagement with the NRC continue to be strengthened
  - The Subcommittee strongly recommends that DOE NE continue to refine the specific strategy for DOE reactor irradiations and PIE including input from the regulator as to what data are required for rendering regulatory decisions
  - The Subcommittee recommends that a roadmap be prepared for the business case of commercialization

EPRI Presentation

- EPRI provided a historical perspective and a current update on efforts to assess the potential benefits of Accident Tolerant Fuel (ATF) within the existing and newly deploying nuclear fleet
- The Subcommittee is strongly supportive of the EPRI and NEI efforts to assess the efficacy and benefits of ATF within the nuclear industry and appreciates the “heavy lift” that near-term deployment of ATF technology faces
- EPRI valuations only show the positive benefits of ATF notwithstanding the economic costs.
- Recommendation:
  - the Subcommittee believes a more even-handed presentation of ATF impacts, identifying the required data and additional evaluations required to support ATF deployment, would instill greater overall confidence in the study results both within the nuclear industry and with the general public

Versatile Test Reactor (VTR)

- The Project Manager (PM) for the Versatile Test Reactor (VTR) provided an overview presentation. The VTR Project seeks to provide experimental capabilities that will benefit advanced reactor design concepts particularly in fuels and materials testing
- There needs to be a planning and parallel activity to engage and develop the potential community that would use the VTR for future experiments
- Conclusions:
  - The approach taken by the VTR PM is encouraging and the Subcommittee agrees with the DOE plan to identify and hire an on-site federal project manager
  - The Subcommittee had previously recommended that the project develop a clear regulatory approach for the VTR. We were pleased to hear that this has been accomplished
  - The Project has the challenge of adapting the PRISM design, which is a design for a power reactor, to that of the VTR test reactor.
  - Current cost estimates for the VTR range between $3B and $6B, which will make this project the largest capital project in the history of DOE-NE.

Versatile Test Reactor (VTR) (cont'd)

- Recommendations:
  - The Project needs to develop a best-cost estimate and an associated design, construction, testing and operation schedule. CD-1 will accomplish this cost estimate.
  - To provide a sound basis for the latter, the Project needs to develop an integrated, resource-loaded schedule with all elements through construction.
  - The Project should also identify the critical path within this schedule along with potential areas that could delay the project (including contingency plans)
  - The Project has been successful in developing a Laboratory-University-Industry team to develop future experiments for the VTR. The Subcommittee recommends that the project develop an engagement plan to identify additional industrial customers reflecting their needs.
  - Because of the magnitude of this project, it would benefit from multi-year funding. It is strongly recommended that the potential benefits of multi-year funding be assessed and identified

ZIRCEX

- The future of nuclear power requires providing a comprehensive fuel cycle for the diversity of reactors in development
- Most advanced reactors require fuel/cladding systems that differ from those used in traditional light water reactors, which is driving the need for HALEU
- Idaho National Laboratory is piloting the recovery and down-blending of HEU from several “end-of-life” fuels previously intended for disposition, including EBR-II fuel, ATR fuel, and Naval Reactor fuel
  - Among the processes being developed is a modification of the ZIRCEX process, originally developed in the 1960s for the separation of uranium from U-Zr alloys
- A long-term schedule is projected incorporating demonstration in the pilot plant (into 2021), followed by design, construction, and operation of a full-scale facility. DOE intends this as a demonstration and bridge to future enrichment options. Other challenges remain, including the concern that no certified shipping containers exist for HALEU.

NEUP

- Since FY09, NE has designated up to 20 percent of the funds appropriated to its R&D programs be applied to university-led R&D and associated infrastructure projects
- These R&D projects are awarded through an open, competitive solicitations process, which is managed by the Nuclear Energy University Program (NEUP)
- NEUP R&D awards have been made to over 100 U.S. universities
  - These R&D awards have also supported 1,716 students (716 PhD, 599 Masters and 401 Undergraduate degrees) since 2009.
  - Sixty U.S. universities have received General Scientific Infrastructure grants to improve lab equipment and capabilities
  - All 25 U.S. university research reactors have been funded for reactor improvements through the Infrastructure Reactor Upgrade program
- It is notable that the NEUP awards have broadened the engagement of the DOE with more universities than in the past, particularly through awards to teams of institutions. Such expansion of engagement is important to diversification of the talent pipeline.

NEUP (cont'd)

- Persistent and balanced support for university research funding is essential to sustaining our technological edge and maintaining our leadership in the global community, in addition to educating and preparing the future workforce of nuclear engineers
- Recommendation:
  - We strongly recommend that NE reexamine its method of dealing with short-term budget issues and not single out and penalize the NEUP disproportionately. The NEUP should be restored to its historic 20% of NE R&D funds in FY20.

Nuclear Science User Facilities

- NE established NSUF in 2007. Today, NSUF involves INL and 20 partner institutions that include facilities from 11 universities, 7 National Laboratories, the Center for Advanced Energy Studies (that include 4 additional universities), and 1 industry partner
- With one key exception, NSUF operates like a typical national user facility:
  - there is no cost to the user
  - there is a competitive, peer-reviewed proposal process for user access, and
  - NSUF funding is not allocated directly to the user, but provided to the facility for the approved user experimental access
- The key difference between NSUF and other national user facilities is that there is no funding provided to the facilities from NSUF for base support of the facility
- NSUF is divided into two components: (1) Consolidated Innovative Nuclear Research (CINR), and (2) Rapid Turnaround Experiments (RTE)
- The Subcommittee's observation is that NSUF is a well-run program that is under-funded given the obvious demand for instrument and reactor time

Nuclear Science User Facilities (cont'd)

- The Subcommittee recommends that NE-5 convene a high-level committee comprised of nuclear scientists and engineers from academia, national laboratories and industry with the following charge:
  - (1) Assess the current suite of NSUF capabilities to interrogate/examine fuels and irradiated materials
  - (2) Analyze the usage and productivity of current NSUF sites
  - (3) Evaluate how well the NSUF enterprise is serving its users
  - (4) Make recommendations for developing a process to make capital investments in the most needed upgrades to instrumentation and capabilities

Thank you –

Questions