U.S. DEPARTMENT OF ENERGY | Nuclear Energy

Science and Technology Innovation (NE-4) Program Overview

Shane Johnson
Deputy Assistant Secretary
Office of Science and Technology Innovation
U.S. Department of Energy

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

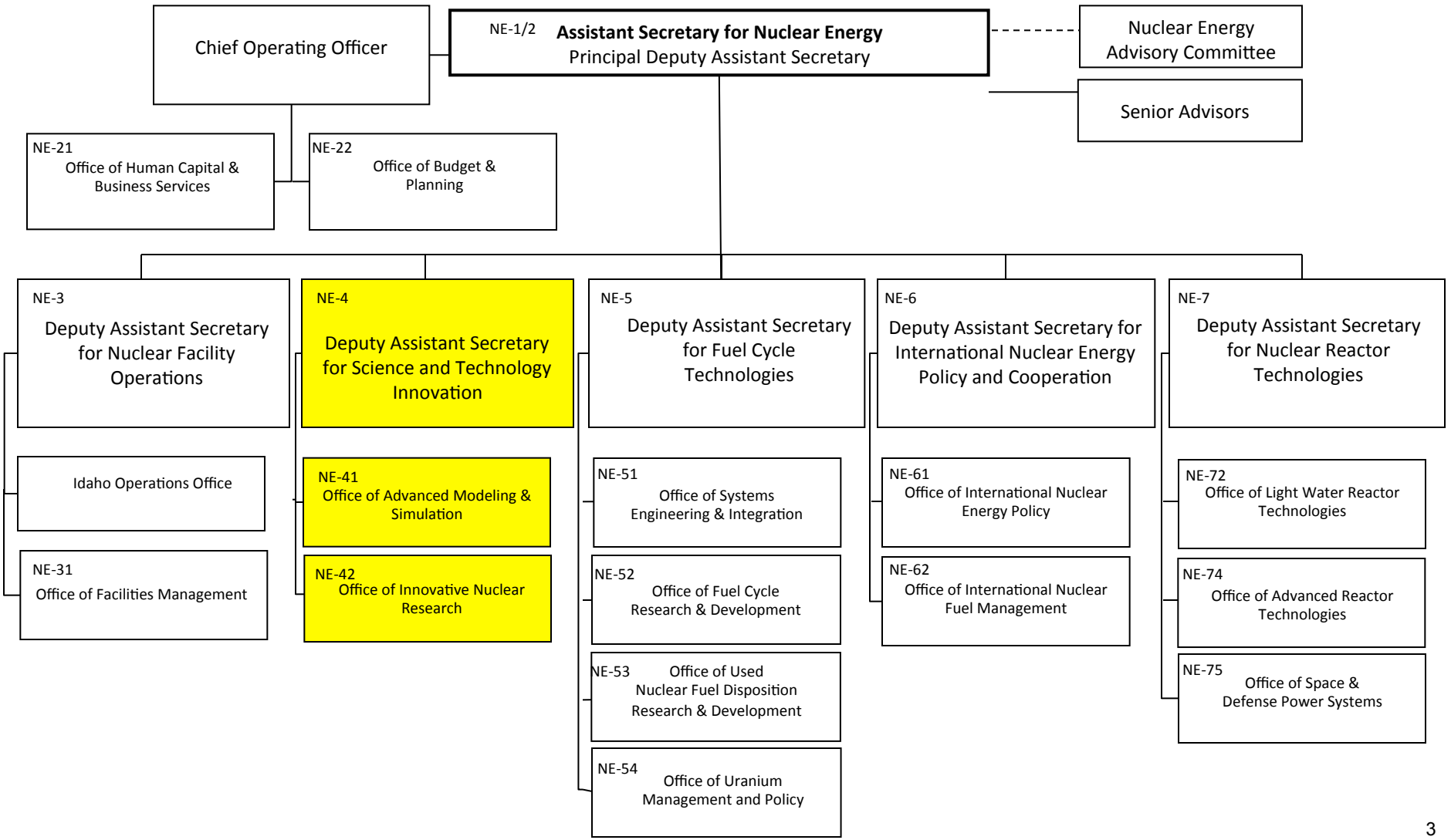
Outline

- Science and Technology Innovation
- Nuclear Energy Enabling Technologies
- National Scientific User Facility
- Research Reactor Infrastructure
- Small Business Innovation Research and Small Business Technology Transfer
- Advanced Modeling and Simulation R&D

U.S. DEPARTMENT OF ENERGY

Nuclear Energy

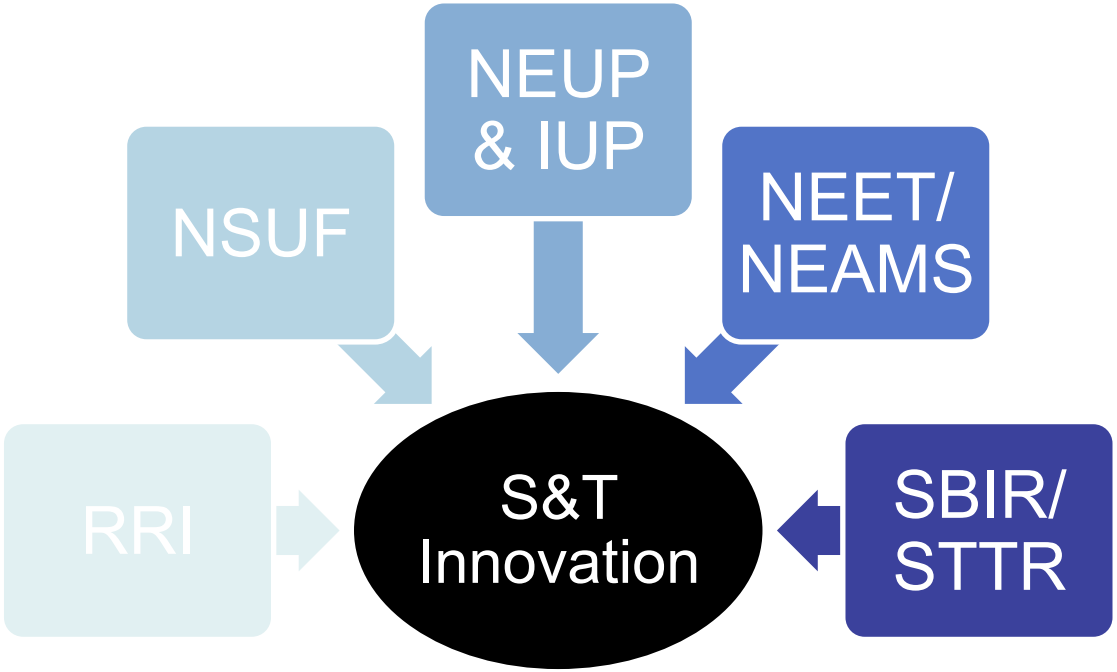
Proposed Reorganization



Science and Technology Innovation

Vision

- Coordinate Office of Nuclear Energy (NE) competitive research
- Work with NE R&D Programs to integrate all research and foster a balanced portfolio



U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Nuclear Energy University Programs

- **The Nuclear Energy University Programs (NEUP) and the Integrated University Program (IUP) have a well established competitive process for awarding R&D, infrastructure and scholarships/fellowships.**

- **The Office of Science and Technology Innovation will continue implementing this competitive process.**

- **The NE R&D Programs are the cognizant technical managers of these competitive R&D awards and therefore play in integral role in the success of each project.**
  - Universities are strongly encouraged to actively engage and collaborate with the associated NE R&D programs.

U.S. DEPARTMENT OF ENERGY | Nuclear Energy

Nuclear Energy Enabling Technologies (NEET)

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

NEET Goal and Objectives

Goal: Address critical technology gaps relevant to multiple reactor and fuel cycle concepts

Objectives:

- Conduct research to develop crosscutting technologies that directly support and complement the Office of Nuclear Energy's development of new and advanced reactor concepts and fuel cycle technologies
- Focus on innovative research relevant to multiple reactor and fuel cycle concepts that offer the promise of dramatically improved performance

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

NEET Crosscutting Technologies

- **Provide R&D solutions to support reactor and fuel cycle technologies:**

  - *Reactor Materials:*
    New classes of alloys and materials not yet considered for reactor performance may enable transformational reactor performance.

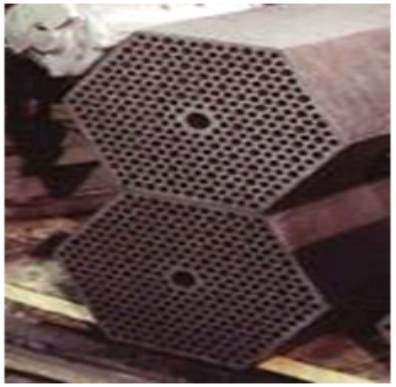
  - *Advanced Sensors and Instrumentation:*
    Research on unique sensor and instrumentation infrastructure technology to monitor and control new advanced reactors and small modular reactor systems.

  - *Advanced Methods for Manufacturing:*
    Research on advanced manufacturing technologies that draw upon successful practices in oil, aircraft, and shipbuilding industries, as appropriate, and employ modeling and simulation capabilities.

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Reactor Materials

- **Three main thrusts to support materials research:**
  - Develop Innovative Materials
    - Alloy development, techniques, and computation
    - "Out of the box" thinking and materials
  - Promote Modern Materials Science Tools
    - Deploy and expand use of new tools
    - Broader tools for all NE Materials efforts
  - Enhance collaboration and cooperation
    - Increased communication between agencies
    - Promotion of international cooperation



- **Under this program, materials are sought that:**
  - Improve mechanical performance by a factor of 5-10 over traditional materials
  - Increase maximum operating temperatures (> 200ºC), over an 80 year lifetime
  - Increase radiation tolerance beyond 300 dpa

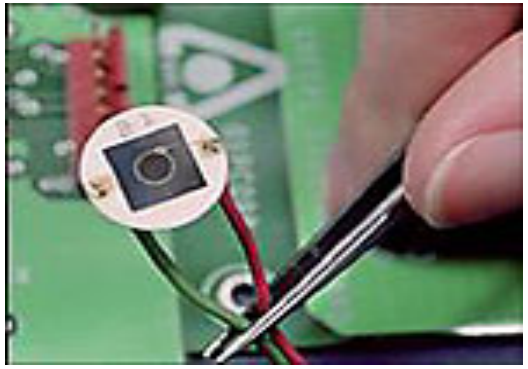
- **High-risk/reward and transformational concepts are appropriate for NEET.**

- **Evolutionary gains are appropriate for the individual programs.**

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Advanced Sensors and Instrumentation

- **R&D to address the unique sensor, instrumentation, and related technology needs to monitor and control new advanced reactors, small modular reactor systems, and fuel cycle facilities.**

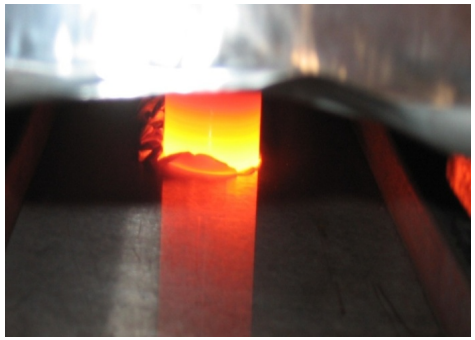


- **Research goals:**
  - Novel measurement capabilities
  - Adaptive and resilient digital monitoring and control
  - Robust communication technologies and architectures
  - Intelligent automation and adaptive interface capabilities

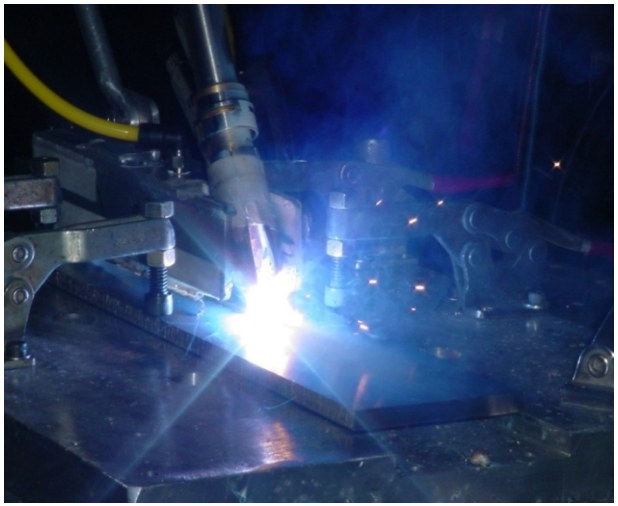
U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Advanced Methods for Manufacturing

- **Vision:**
  - Improve the methods by which nuclear equipment, components, and plants are manufactured, fabricated, and assembled by utilizing practices found in industries such as oil, aircraft, and shipbuilding



- **Goals:**
  - Reduce the cost and schedule for new nuclear plant construction
  - Make fabrication of nuclear power plant (NPP) components faster, cheaper and more reliable



- **Technical research:**
  - Joining processes
  - Near-net shape fabrication techniques
  - Advanced concrete construction methods
  - Support SMRs, conventional plants and modular construction

U.S. DEPARTMENT OF ENERGY | Nuclear Energy

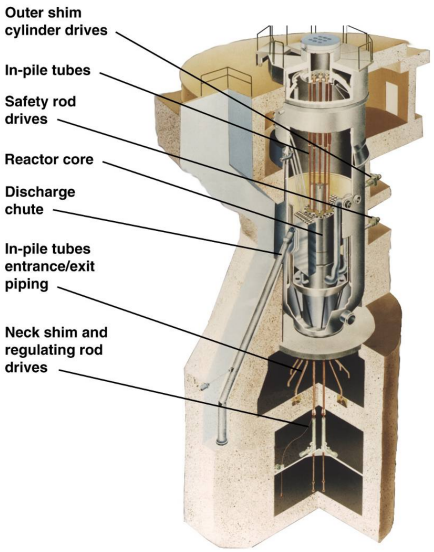
National Scientific User Facility (NSUF)

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

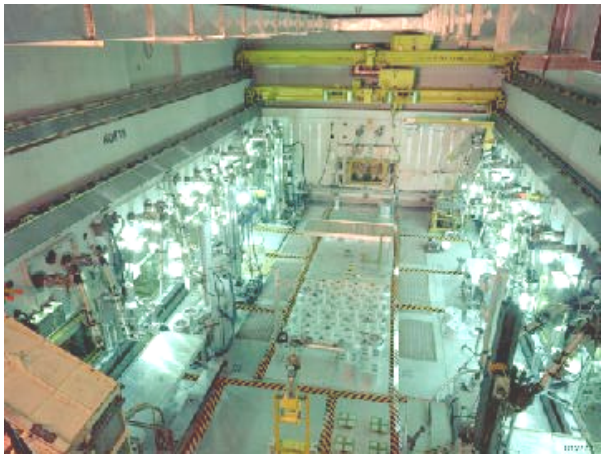
Vision for the NSUF

- ***Provide the research community a means to conduct cutting edge nuclear technology R&D.***
- ***Allow the research community access to existing test reactor space and post-irradiation examination capabilities, supported by the Department of Energy***

Advanced Test Reactor (ATR)



INL radiation Examination (PIE) Facilities



U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Expansion of NSUF

- **The National Scientific User Facility was initially limited to the ATR and the Idaho National Laboratory post-irradiation examination (PIE) capabilities.**

- **Because test reactor space and capabilities for examining radioactive materials are limited, a network of capabilities across the U.S. is necessary.**
  - Includes participants from both national laboratories and universities across the U.S.
  - Includes reactor irradiation, accelerator irradiation, and PIE capabilities

- **In FY12, a process was developed to allow researchers to submit a single proposal through both NSUF and NEUP for a single research proposal.**

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

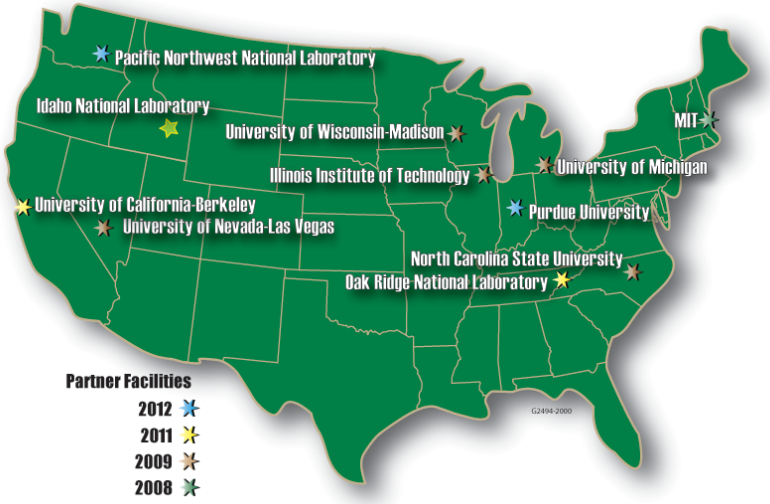
NSUF Partnerships

- **Partnership Objectives**
  - Higher utilization of partner facilities
  - Support educational initiatives at the university (faculty research, student participation)
  - Meet customer needs
- **NSUF includes additional capabilities to benefit users**
  - University research reactors
  - Hot cells or hot laboratories
  - Accelerator facilities
- **Partnership Selection Process**
  - Potential partners self-nominate
  - Evaluation (3 peer reviewers) and selection based on value of added capability to user community
  - Capabilities added to next proposal solicitation
- **Partnerships developed over several years – several facilities added each year**
- **Also piloting a process to have a joint solicitation with Argonne National Laboratory's Advanced Photon Source**

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

NSUF Partnerships

- **Reactor/Irradiation Facilities**
  - Massachusetts Institute of Technology Reactor
  - North Carolina State University, PULSTAR Reactor
  - Oak Ridge National Laboratory (ORNL), High Flux Isotope Reactor (HFIR)
- **Post Irradiation Examination**
  - North Carolina State University
  - University of Wisconsin
  - University of Michigan
  - UC Berkeley
  - University of Nevada, Las Vegas
  - ORNL
  - Purdue
  - Pacific Northwest Nuclear Laboratory
- **Beamline Facilities**
  - University of Wisconsin
  - Illinois Institute of Technology (Advanced Photon Source)
  - University of Michigan
  - North Carolina State University, PULSTAR Reactor



U.S. DEPARTMENT OF ENERGY | Nuclear Energy

Research Reactor Infrastructure

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

RRI Mission and Objectives

Mission

- The mission of the Research Reactor Infrastructure program is to provide fresh fuel and spent fuel services to the university research reactors that require fresh fuel during their operating lifetimes and the disposal of spent fuel to DOE disposal storage sites. This authority is granted under Section 31 of the Atomic Energy Act.

Objective

- To fabricate fresh fuel elements for 26 university reactors and dispose of used fuel from university reactors to DOE disposal sites

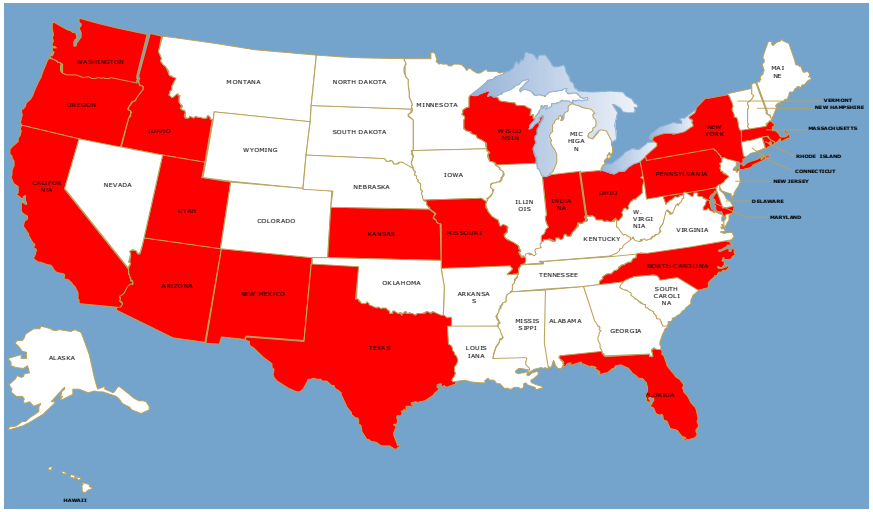
Strategic Linkage

- Supports the Department's Secretarial priorities by conducting activities focused on sustaining and expanding safe and secure nuclear energy production

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

RRI Technical Focus Areas

- **Fuel Fabrication**
  - Provides fresh fuel for university research reactors
  - Procures uranium feedstock
- **Fuel delivery/retrieval**
  - Provide transportation for fresh fuel and used research reactor fuel
- **Equipment repairs, as needed**



Map with states with universities supported by RRI highlighted

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

List of RRI Universities

- **University Research Reactors supported by this program include:**

Massachusetts Institute of Technology
Purdue University
University of Florida
University of Missouri (MURR)
Worcester Polytechnic Institute
University of California at Irvine
University of Maryland
Penn State University
University of Texas at Austin
University of Utah
University of Wisconsin
Idaho State University
North Carolina State University
Ohio State University
Rhode Island Nuclear Science Center
University of Massachusetts at Lowell
University of Missouri at Rolla
University of Arizona
Kansas State
Oregon State University
Reed College
Texas A&M University
Washington State University
University of California Davis
University of New Mexico
Rensselaer Polytechnic

U.S. DEPARTMENT OF ENERGY | Nuclear Energy

Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR)

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

SBIR/STTR Program Description

Program Objectives

- Increase private sector commercialization of technology developed through DOE-supported R&D, stimulating technological innovation in the private sector, and improving the return on investment from Federally-funded research for economic and social benefits to the nation.

General Program Requirements

- 3.05% of FY 2013 R&D budgets (2.7% SBIR, 0.35% STTR)
- Office of Science administers Phase I and Phase II processes
- Each DOE office has a designated SBIR Portfolio Manager
- Only U.S. small businesses are eligible to submit SBIR/STTR applications
  - Collaborators may include; DOE National Laboratories & Research Institution
- All Phase I & II applications must be submitted through www.grants.gov

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

SBIR/STTR Project Phases

- **Phase I:**
  - Awards explore the feasibility of innovative concepts with awards up to $150K for up to 9 months.
  - Success in Phase I is a prerequisite to further DOE support in Phase II.
- **Phase II:**
  - Awards focus on developing concepts that are determined to be feasible through completion of Phase I.
  - NE awards are up to $1M for up to 24 months.
- **Phase III:**
  - Awards are focused on commercial application of technologies supported in Phase II.
  - Projects are funded by NE R&D programs
    - This is outside the 3.05% SBIR/STTR set aside.

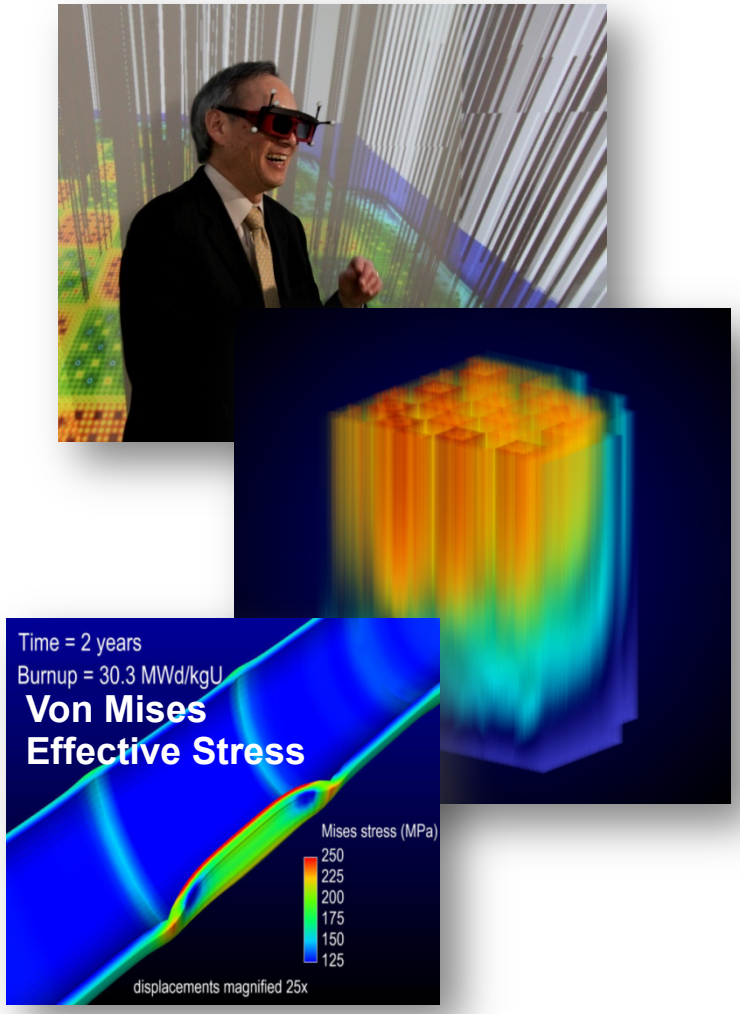
U.S. DEPARTMENT OF ENERGY | Nuclear Energy

Advanced Modeling and Simulation R&D

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Advanced Modeling and Simulation for Nuclear Energy

- Provides the ability to gain new insights about the performance and safety of nuclear energy technologies
- Works in partnership with theory and experiment to enhance NE R&D
- Develops simulation toolsets for use by R&D community and industry to impact existing, near-term and future reactors



U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Advanced Modeling and Simulation Programs

NEAMS (Nuclear Energy Advanced Modeling and Simulation)

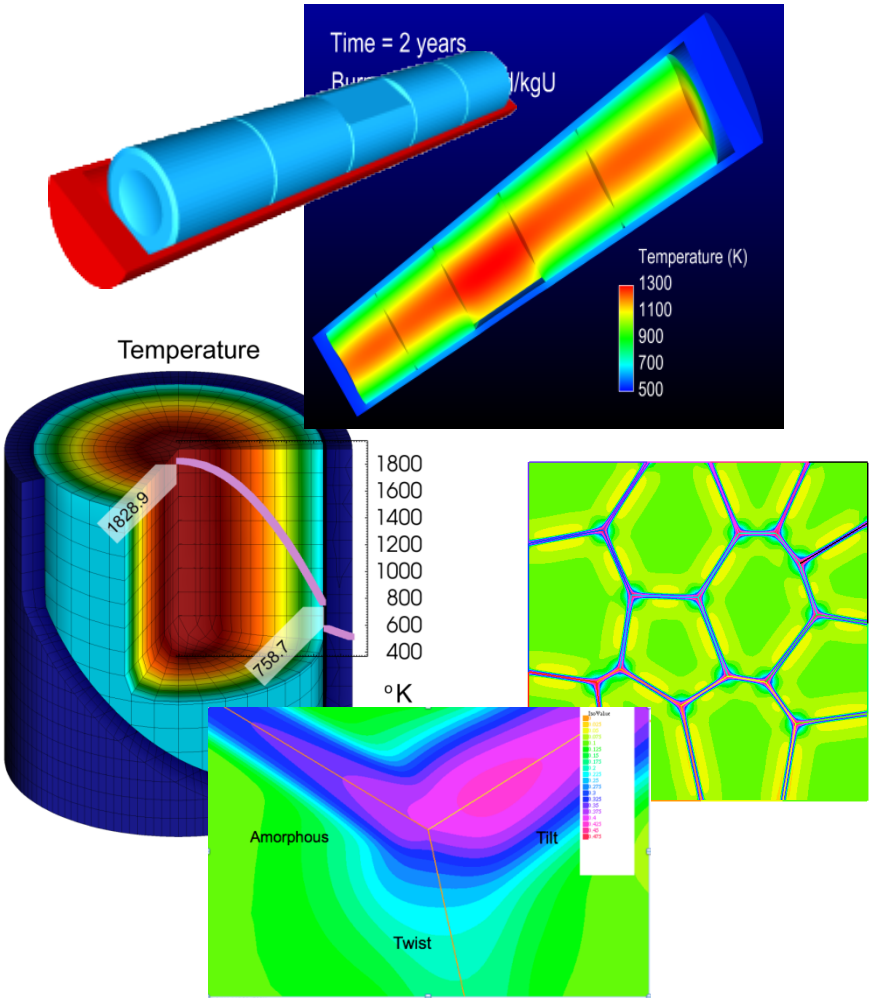
- Focused on developing simulation capabilities for advanced reactors (non-LWR) and fuels
- Developing a comprehensive "pellet-to-plant" simulation toolkit
- Part of the NE approach to implementing a science-based approach to R&D

CASL (Consortium for the Advanced Simulation of LWRs)

- Focused on existing, operating reactors (LWRs)
- Developing a "virtual reactor" tool to address limiting safety and operating issues in existing PWRs
- One of the DOE Energy Innovation Hubs
- Work coordinated with the NEAMS program

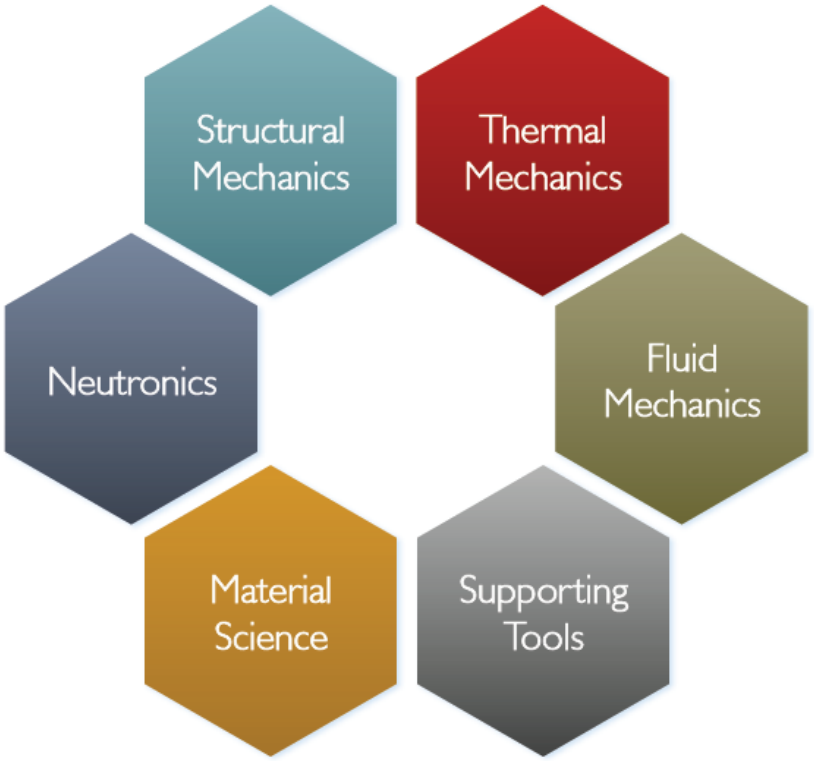
NEAMS – Fuel Product Line

- **Extends functionality of FRAPCON/ FRAPTRAN with mechanistic based behavior models**
- **Modern computational technology and up-to-date computer hardware**
  - Advanced fuel designs
  - Accident-tolerant fuels research
  - Can be extended to simulate behavior of used fuel in long term storage



NEAMS – Reactor Product Line

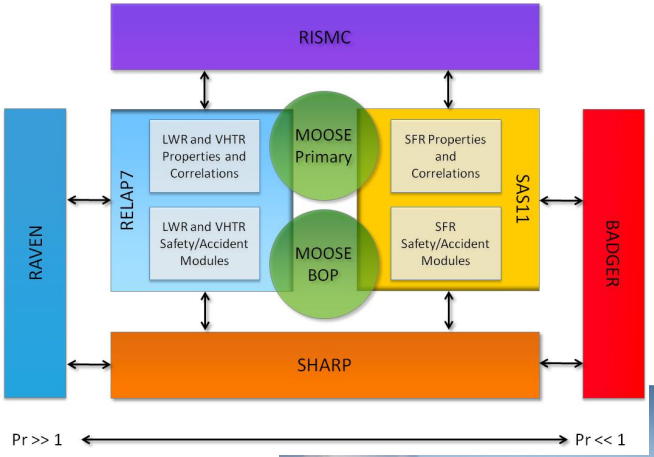
- **Provides a 3D, high-fidelity, coupled-physics simulation capability for advanced reactors (non-LWR)**
  - Understand complex, coupled phenomena that are hard to model and measure
  - Perform conceptual design studies on advanced reactors of all types
  - Study safety behavior with high-fidelity, coupled neutronics, thermal-fluids, thermal-mechanics, and fuel models
  - Provide accurate solutions for code-to-code comparisons with lower-fidelity models
  - Demonstrate advanced validation and uncertainty quantification approaches

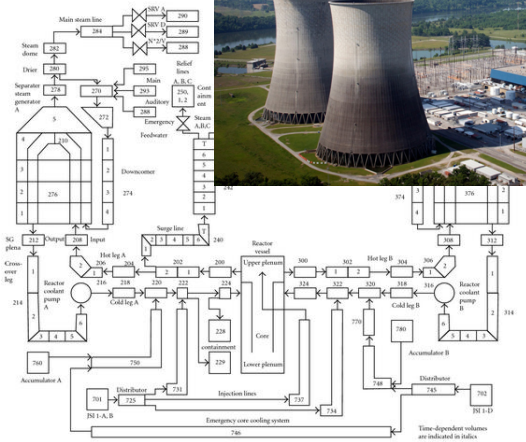


U.S. DEPARTMENT OF ENERGY
Nuclear Energy

NEAMS – RELAP7

- **Co-funded by LWRS and NEAMS**
- **Follow-on to RELAP-5**
- **Integrated with high resolution NEAMS reactor toolset (SHARP)**
- **Used to understand plant safety issues for**
  - Existing plants and life extensions
  - New Gen III and III+ builds
  - Adopted by CASL to understand connections between reactor core and plant safety issues



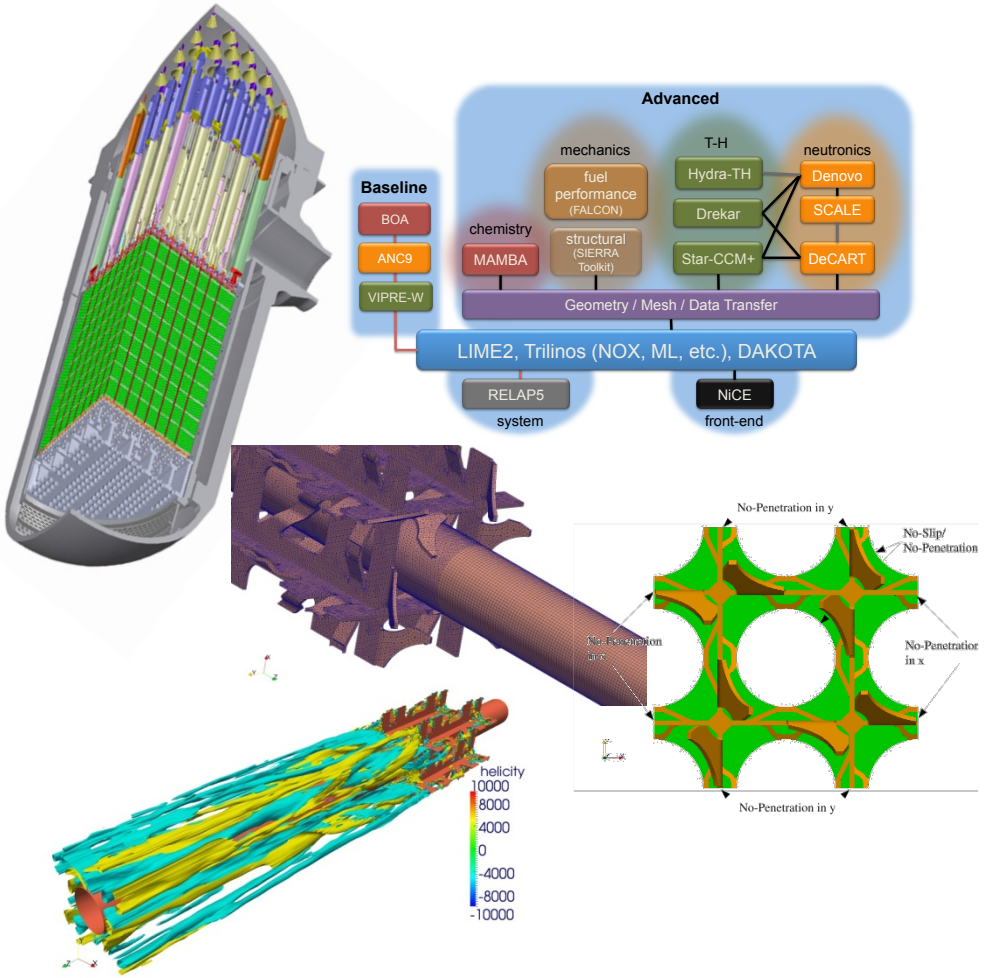


U.S. DEPARTMENT OF ENERGY

Nuclear Energy

CASL - Virtual Environment for Reactors Analysis (VERA)

- **Performed by CASL, a partnership of industry, academia and national labs led by ORNL**
- **Understand safety and performance issues of fuel assemblies in the core of an operating PWR**
  - CRUD formation and power shifts, Grid-to-Rod Fretting, etc
- **Used to support**
  - Power uprates
  - Higher burnup
  - In the second phase (if awarded) support for similar work on BWRs and SMRs



NEAMS FY13 NEUP Workscope

- Development and demonstration of validation methodologies for the NEAMS fuel performance codes
- Validation of fuel performance codes against PWR fuel pin experimental data

Summary

- The Office of Science and Technology Innovation was established to coordinate and integrate competitive and crosscutting research across all NE R&D Programs.
- NEUP and IUP directly support competitive university-based R&D, infrastructure and scholarship/fellowships
- NEET supports crosscutting R&D in support of NE's mission
- NSUF enables national testing capabilities
- RRI supports and maintains national research reactor infrastructure
- SBIR/STTR promotes small business innovative R&D
- Advanced Modeling and Simulation supports a broad range of computational needs