U.S. DEPARTMENT OF ENERGY | Nuclear Energy

Nuclear Energy University Programs (NEUP) Fiscal Year (FY) 2016 Annual Planning Webinar

Mission Supporting Transformative Research Reactor Concepts RD&D (MS-RC1)

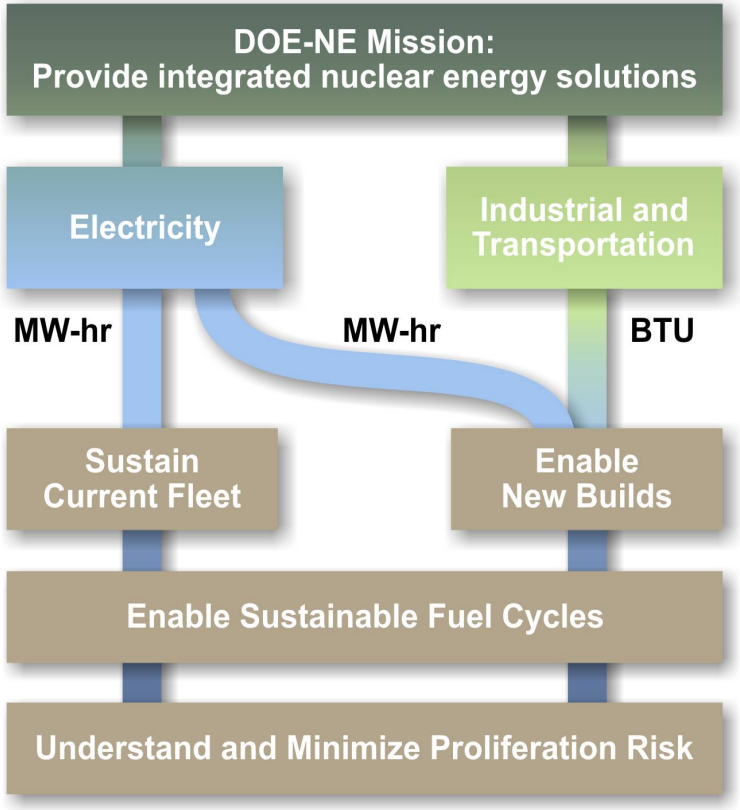
Tom Sowinski
Office of Advanced Reactor Technologies

August 2015

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Office of Nuclear Energy Roadmap R&D Objectives

- **Develop technologies and other solutions that can improve the reliability, sustain the safety, and extend the life of current reactors**
- **Develop improvements in the affordability of new reactors to enable nuclear energy to help meet the Administration's energy security and climate change goals**
- **Develop sustainable nuclear fuel cycles**
- **Develop capabilities to reduce the risks of nuclear proliferation and terrorism**



U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Office of Nuclear Reactor Technologies

- **Mission: Keep current fleet operating safely and develop new nuclear technologies for deployment**
  - Promote technologies that have greatest promise to enable new nuclear power
  - Conduct R&D to maintain safe operation of existing fleet
  - Honor commitments to other Federal agencies, International partners and universities
  - Maintain unique capabilities and facilities to support future USG policy decisions and industry needs
  - Explore new high-risk, high-reward technologies
- **NE- 7 consists of three Offices:**
  - NE-72: Light Water Reactor Technologies – Rebecca Smith-Kevern
  - NE-74: Advanced Reactor Technologies (ART) – Tom O'Connor
  - NE-75: Space and Defense Power Systems – Alice Caponiti
- **Research activities are designed to address technical, cost, safety, and security issues associated with various reactor concepts**

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Reactor Concepts Portfolio

Office of Science and Technology Innovation
NE-4

Office of Fuel Cycle Technologies
NE-5

Deputy Assistant Secretary for Nuclear Reactor Technologies NE-7

Light Water Reactor Technologies

- LWRS
- SMR LTS

Advanced Reactor Technologies

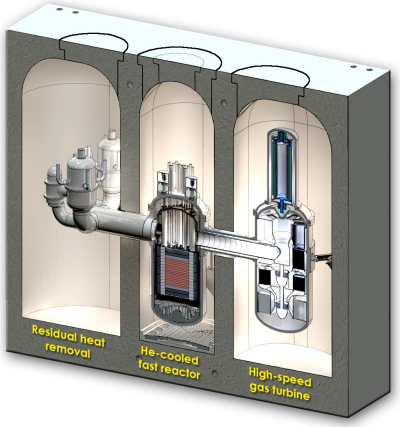
- Fast Reactor Technologies
- High Temperature Reactor Technologies
- Advanced Reactor Generic Technologies
- Advanced Reactor Licensing Framework
- Advanced Reactor System Studies

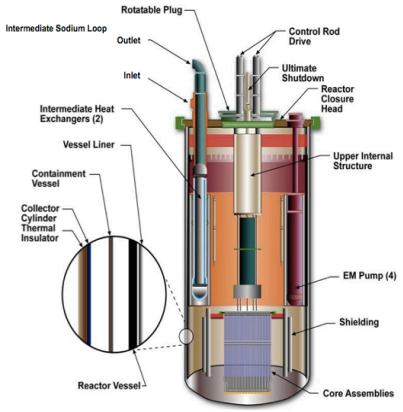
Space and Defense Power Systems

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

ART Focus Areas

- **Fast Reactor Technologies**
  - For actinide management and electricity production
  - Current focus on sodium coolant
- **High Temperature Reactor Technologies**
  - For electricity and process heat production
  - Current focus on gas- and liquid salt-cooled systems
- **Advanced Reactor Generic Technologies**
  - Common design needs for advanced materials, energy conversion, decay heat removal systems and modeling methods
- **Advanced Reactor Regulatory Framework**
  - Development of licensing requirements for advanced reactors
- **Advanced Reactor System Studies**
  - Analyses of capital, operations and fuel costs for advanced reactor types





U.S. DEPARTMENT OF ENERGY
Nuclear Energy

ART Research Questions

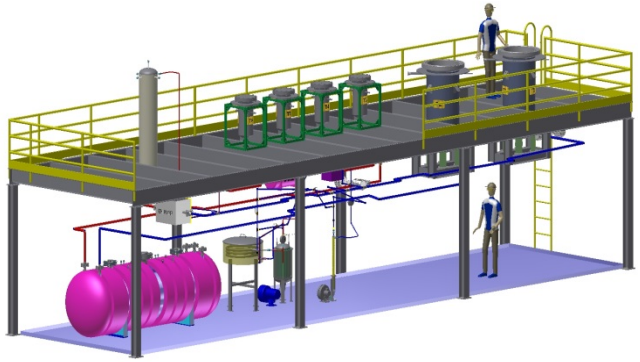
Working to address several high level questions to advanced reactor development and deployment:

- How can we improve **affordability** of nuclear power?
- How can we improve **inherent safety** of advanced nuclear reactors?
- How can we improve **proliferation resistance** of advanced reactors?
- How can we address nuclear waste through **advanced fuel cycle** options?
- How can we expand into **non-traditional nuclear energy markets**?
- How can we **increase performance and efficiency** through new materials, advanced systems or components?

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Fast Reactor Technologies

- **Concept Development and Technology Maturation**
  - Assessments to guide innovative R&D
  - Conduct of small-scale sodium fast reactor component testing at Materials Engineering Testing Laboratory (METL)

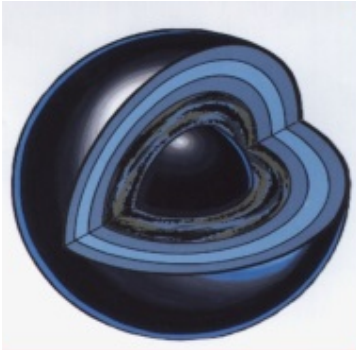


- **Advanced Materials**
  - Intermediate term testing of two candidate alloys currently in progress
- **Advanced Energy Conversion Interface System**
  - Sodium to Supercritical CO2 Interaction loop at ANL
- **Safety and Risk Reduction**
  - Licensing aspects
  - Capital Cost Risk Reduction (International Collaborations and Industry Partnerships)
- **Ultrasonic Viewing Technology**
  - Key for under-sodium inspection

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

High Temp Reactor Technologies
High Temp Gas Reactor (HTGR)

- **Fuel Qualification**
  - Ongoing work to establish licensing basis for coated particle fuel (TRISO) and commercial fabrication capability
  - Accident testing performed at 1600°C, 1700°C and 1800°C with no failures

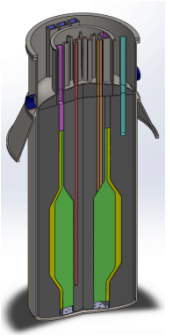


- **Passive Decay Heat Removal Modeling**
  - Natural Convection Shutdown Heat Removal Test Facility (NSTF) at ANL evaluates ex-vessel passive decay heat removal system performance
  - High Temperature Test Facility (HTTF) at Oregon State University will verify and validate thermal fluids modeling programs from fuel to pressure vessel wall

- **Materials**
  - High temperature materials
  - Graphite

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

High Temp Reactor Technologies
Fluoride High Temp Reactor (FHR)



- **FHR R&D primarily funded through Integrated Research Projects (IRPs)**
  - Two Recent IRPs awarded in 2014 to investigate key technology and design challenges associated with FHRs
    - Team from Massachusetts Institute of Technology, University of California, Berkeley, and the University of Wisconsin on materials, neutronics, and tritium management
    - Team from Georgia Institute of Technology on licensing and technology challenges
- **International Collaboration**
  - Collaborations with China on their FHR test reactor activities
  - Collaborations with Czech Republic to support their test program with salts provided by DOE in 2013

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Mission Supporting Reactor Concepts Work Scope Description (MS-RC1)

REACTOR CONCEPTS RD&D (MS-RC1) (FEDERAL POC – TOM SOWINSKI, TECHNICAL POC – BOB HILL)

Development of new reactor concepts that may offer the potential for *revolutionary improvements to reactor performance and/or safety* is sought. Such advanced reactor concepts could include:

- **Incorporation of advanced systems or components into existing concepts (e.g. Generation-IV systems)**
- **Inclusion of innovative design alternatives (e.g., new fuel type, nano-engineered coolants, etc.)**
- **Designs employing radically different technology options (e.g., advanced coolants, fuel, or operational regimes).**
- **Reactors with unique capabilities to address operational missions other than the delivery of base load electric power, such as desalination or mobile reactors**

The scope of the proposed project should include an assessment of the concept's technical viability, a detailed technology gap analysis, and a comprehensive technology development roadmap that identifies research needed on key feasibility issues.

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Recent MS-RC1 Awards

FY14

- Feasibility assessment of an innovative compact reactor concept that integrates power production, power conversion and electricity generation in a single unit

FY13

- Feasibility study of breed and burn pebble-bed metal cooled reactor offering a significant increase in the uranium ore utilization versus contemporary light water reactors without need for fuel reprocessing and recycling.
- Tritium mitigation and control systems for FHRs.

FY12

- Fuel and Core Design Options to Overcome the Heavy Metal Loading Limit and Improve Performance and Safety of Liquid Salt Cooled Reactors
- Stationary Liquid Fuel Fast Reactor Concept for TRU Burning
- ABR for TRU Transmutation with Breed & Burn Thorium Blanket for Improved Economics and Resource Utilization

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

FY 2016 MS-RC1 Summary

- **A variety of reactor technologies are being pursued in the current DOE-NE R&D portfolio**
  - High temperature gas-cooled and sodium-cooled reactors
  - Liquid salt reactors via FY 2011 IRP and FY 2014 IRP
  - Different technologies reviewed by Technical Review Panel http://www.energy.gov/sites/prod/files/2014/12/f19/Advance%20Reactor%20Concepts%20Technical%20Review%20Panel%20Public%20Report.pdf

- **MS-RC1 scope includes**
  - Major innovations to advanced reactors concepts
    - Advanced systems or components
    - New fuel types or engineered coolants
  - Radically different (new) technology options
    - Innovative operating regimes
    - Unique capabilities other than base-load electric production

Questions?