



U.S. DEPARTMENT OF
ENERGY

Nuclear Energy

DOE Advanced Reactor Initiatives

Workshop on Advanced Reactor Licensing

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April 25, 2017

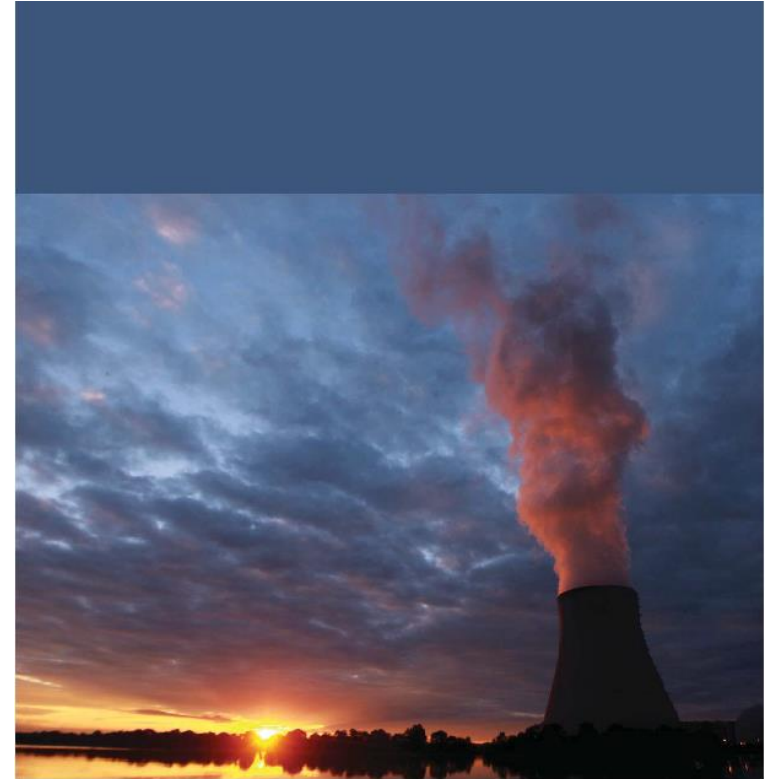


DOE Vision and Strategy

DOE issued its “VISION and STRATEGY for the Development and Deployment of Advanced Reactors”

<https://energy.gov/ne/downloads/vision-and-strategy-development-and-deployment-advanced-reactors>

- Complementary with NRC’s Implementation Action Plan
- Includes a near term focus on an NRC regulatory framework being established for advanced non-LWRs



VISION and STRATEGY
for the Development and Deployment of Advanced Reactors

Priorities for Advanced Reactors

- **Work with NRC and industry to develop a framework for advanced reactor licensing**
- **Make DOE assets and expertise available to industry and academia via the GAIN Initiative**
- **Conduct cutting edge research to enable the commercial deployment of advanced reactors by the 2030's**
- **Applying Modeling and Simulation tools suitable for analysis of advanced reactor systems**

Establishing a Regulatory Framework for Advanced Reactors

Key constituents of a regulatory framework that will increase regulatory certainty for advanced reactors include:

- **Identify and resolve key Commission policy issues**
- **Adapt LWR-based regulatory requirements to advanced non-LWRs**
 - Informed by results of DOE's focused R&D activities
- **Establish Licensing Technical Requirements**
 - Enhanced by development of industry consensus Codes & Standards
- **Establish staged/phased review processes**

Gateway for Accelerated Innovation in Nuclear (GAIN)

- **GAIN was created to provide access to state-of-the-art DOE capabilities for nuclear energy**

- **GAIN facilitates workshops and meetings to advance understanding of needs and abilities**

- **New round of GAIN Vouchers announced**
 - Letters of intent by **March 9, 2017** were encouraged
 - RFA submittal period **March 13 – April 10, 2017**
 - Anticipate funding as many as 20 vouchers for FY2017, subject to appropriation

<https://gain.inl.gov>

Advanced Reactor Technologies Focus Areas

■ Fast Reactor Technologies

- For actinide management and electricity production
- Current focus on sodium coolant

■ Gas Reactor Technologies

- For electricity and process heat production

■ Molten Salt Reactor Technologies

- Commonalities across multiple R&D technologies

■ Advanced Reactor Demonstration and Industry Awards

- Continued support for ARC 15 awards
 - X-energy
 - Southern Company



Fast Reactor Technologies

■ Demonstrate feasibility of advanced systems and component technologies

- Mechanisms Engineering Test Loop (METL) facility at ANL – multiple test vessels for component testing in prototypic conditions
 - In FY17, commissioning, start-up testing and introduction of first test assembly
 - Locations available for industry-defined component, materials or equipment testing
- Development of under-sodium inspection techniques and instruments



Na-CO₂ Interaction Loop
at Argonne National
Laboratory

■ Methods and code validation to support design and licensing

- Detailed analysis and international benchmarking of fast reactor safety tests conducted at demonstration reactors
- Safety analysis code improvements and validation and verification
- Thermal hydraulic and neutronic code development



■ Advanced materials qualification

- Qualification of alloys for anticipated operation conditions in SFRs
- Material testing for Grade 91 and Alloy 709 for use in fast reactor development
- Structural material testing data exchange with Japan to support code qualification



Mechanisms Engineering Test Loop
(METL) facility at ANL – multiple
test vessels for component testing
in prototypic sodium conditions

■ Fast reactor information recovery and preservation



Gas Reactor Technologies R&D

■ Advanced materials qualification

- Graphite qualification for use in HTRs through a series of baseline characterizations, irradiation creep testing in ATR, irradiated properties testing, and model development
- Approval of ASME code case for Alloy 617 for anticipated operation conditions in HTRs - heat exchangers and steam generators
- Update high-temperature design methods in ASME Code

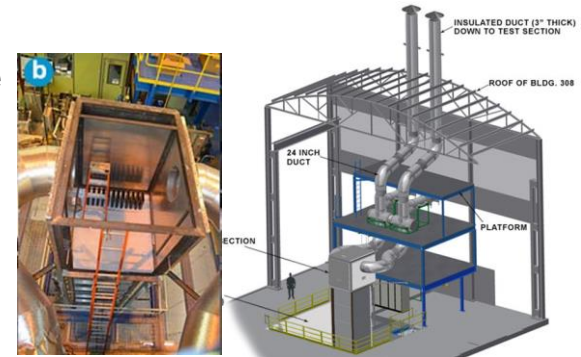
■ AGR fuel qualification program

- Fabrication, irradiation and PIE to verify superior TRISO fuel performance under normal operating and potential accident conditions

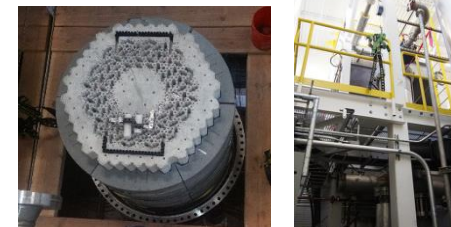
■ Scaled experiments to support design and licensing

- Simulate coolant flow and heat transport in and from HTRs during accident scenarios – code validation to support licensing
 - Natural Convection Shutdown heat removal Test Facility (NTSF) at ANL for severe accident heat removal
 - High Temperature Test Facility (HTTF) at Oregon State University for core thermal hydraulics – heated prismatic block core simulator, $\frac{1}{4}$ scale

■ High Temperature Fission Chamber development



Natural circulation Shutdown heat removal Test Facility (NSTF) for vessel cooling studies



High Temperature Test Facility (HTTF) at Oregon State University

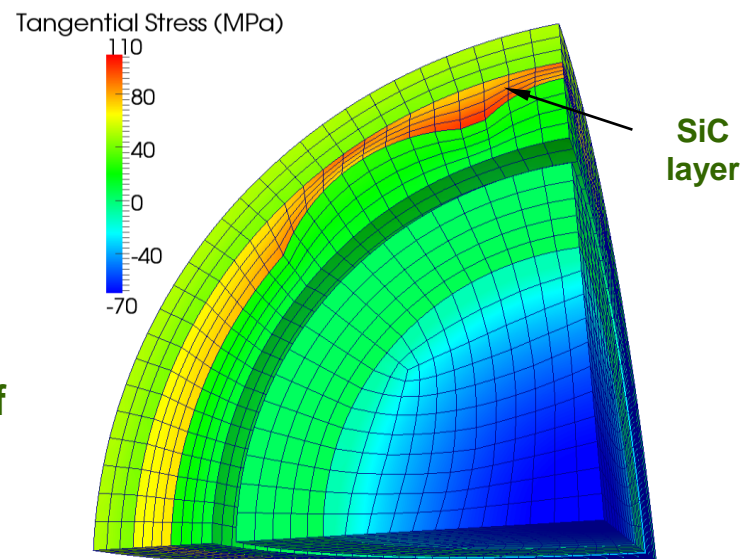
Molten Salt Reactor Technologies R&D

- **Molten salt test loop at ORNL for testing tritium management technology**
- **MSR information recovery and preservation**
- **Other current work funded under university grants and Integrated Research Projects**
 - High-Temperature Salt-Cooled Reactor for Power and Process Heat (2011, MIT, Wisconsin, UC Berkeley)
 - Integrated Approach to FHR Technology and Design Challenges (2014, MIT and Georgia Tech)
- **Future work could include:**
 - Demonstrate the technology viability, component and system reliability, and safety by constructing and operating appropriate test facilities
 - Identify and establish R&D infrastructure (loops, test stands, etc.,)
 - Advanced Materials Qualification
 - ASME code case for Hastelloy N – a high nickel alloy compatible with salt-cooled reactors
 - Methods to allow use of salt-corrosion-resistant clad structural materials
 - Approaches for qualification of liquid fuels
 - Modeling and Validation to support the design, operations, and licensing

Modeling and Simulation

- NEAMS and CASL are major DOE investments in new and improved modeling tools and methods
- Validated modeling and simulation tools hold the potential for accelerating the design and licensing of advanced reactors
- Dr. Stanek will talk to the specifics of modeling and simulation later today

BISON 3D capability demonstrated on an eighth-of-a-particle with localized thinning of the SiC layer at random locations





ARC-15 Awards

Nuclear Energy

■ The X-energy ARC15 project has three main thrusts

- Further the Xe-100 HTGR pebble bed design
- Establish pebble fuel manufacturing capability
- Engage the NRC through white papers and topical reports

First X-energy Pebble (Fall 2016)



■ The Southern Company MCFR Risk Reduction Activities

- R&D in key areas of salt studies, material development and reactor licensing.
- Year 1 develop Separate Effects Test (SET) and conceptual design of the Integrated Effects Test (IET), which will be constructed in Year 3
- IET operations (Years 4-5) will validate the behavior of fuel salt (using depleted uranium) at temperature and with relevant materials.



DOE Advanced Reactor Initiatives:

- **Work with industry and NRC on licensing framework**
- **Leverage GAIN to align advanced reactor R&D with U.S. industry needs**
- **Fund the labs, universities and industry to conduct cutting edge research to close the knowledge gaps**
- **Applying modeling and simulation tools of the future**

Collectively – DOE initiatives are enabling the future of nuclear energy