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HTGR Program Status

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U.S. Department of Energy

IAEA Technical Meeting

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FY 2015 Budget Request for Reactor Concepts Research, Development, and Demonstration

Budget Summary
$ in thousands

Program Element	FY 2014 Enacted	FY 2015 Request
Small Modular Reactor Advanced Concepts R&D*	**22,964**	**--**
Light Water Reactor Sustainability	**29,953**	**30,300**
Advanced Reactor Technology	**59,905**	**70,240**
Total:	112,822	100,540

*SMR Advanced Concepts R&D included in Advanced Reactor Technology starting in FY 2015

Mission

Develop new and advanced reactor designs and technologies that advance the state of reactor technology to improve competitiveness and support meeting Nation's energy , environmental, and national security goals.

FY 2015 Planned Accomplishments

- Release "Beta" version of the RELAP-7 code for industry review and testing to support the Risk Informed Safety Margin Characterization approach.
- Complete mechanistic models that predict Reactor Pressure Vessel embrittlement and irradiation-assisted stress corrosion cracking.
- Provide technical reports to NRC on General Design Criteria related topics and advanced reactor technologies to support the NRC's establishment of an advanced reactor licensing framework.
- Perform TRISO post-irradiation examinations.
- Perform graphite irradiation and post - irradiation examination experiments.
- Complete ASME Code Qualification case proposals for selected advanced reactor materials.

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US HTGR Program Overview

- **Ongoing priority research:**
  - AGR fuel qualification program
  - AGC graphite qualification program
  - High temperature materials qualification
  - Passive heat removal system testing and modeling
- **Interactions with NRC**
  - Review and feedback on priority research activities
  - Establishment of a modular HTGR licensing framework
    - Development of safety design criteria
    - Resolution of other key technical and policy issues (requirements for functional containment, establishment of mechanistic source term, etc.)
- **Engaging with Industry**
  - Developing business models and deployment strategies

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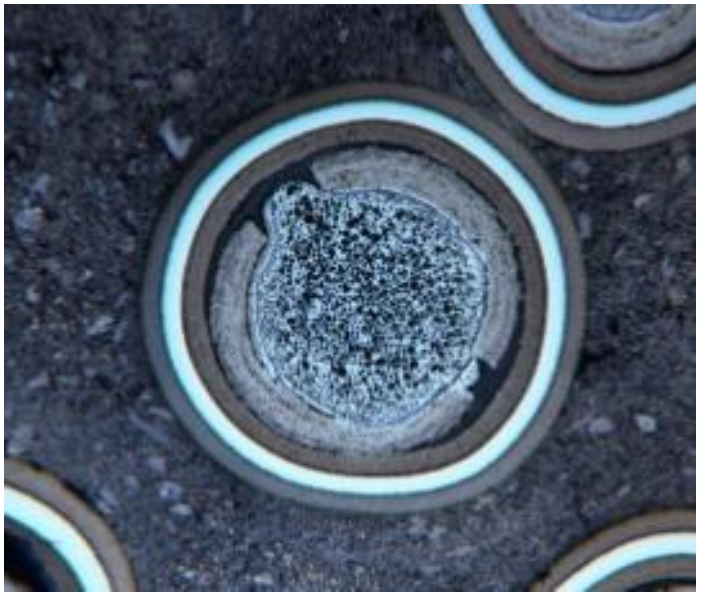
Advanced Gas Reactor (AGR) Fuel Qualification Program

- **Ongoing Multi-Year AGR Program is Focused on Demonstrating:**
  - Fabrication of high-quality low-defect fuel is achievable at industrial scale
  - Robust irradiation performance
  - Robust accident performance
- **Draft NRC Feedback on AGR Program**
  - The scope of AGR Program activities is generally reasonable in context of pre-prototype testing
  - Early AGR irradiation and safety testing results show promise for demonstrating much of desired tristructural isotropic (TRISO) fuel retention capability
  - Additional data are needed from fuel and core testing in a prototype reactor to provide reasonable assurance of targeted fission product retention in fuel



TRISO fuel forms heart of HTGR safety case

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Materials Testing and Qualification

High Temperature Materials Program

- Alloy 800H is being qualified for extended operation up to 850°C and Alloy 617 up to 950°C, which will be adequate for the modular HTGR.
- Improvements in high temperature design methodology are underway to reassess and improve the design margins needed for HTGRs.

AGC – Graphite Testing Program

- Develop the qualification data set of thermo-mechanical and thermo-physical properties for un-irradiated and irradiated candidate grades of graphite for HTGRs.
- Demonstrate the performance of various graphite types under bounding conditions, including irradiation dose levels, anticipated applied stress levels, and maximum core temperatures.
- Provide an improved understanding of graphite irradiation and environmental degradation mechanisms for use in developing improved models of graphite behavior for design and performance.

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Analytical Methods Development

- Continuing to support computational fluid dynamics work as part of the IAEA Coordinated Research Program (CRP) on High Temperature Gas-cooled Reactor Uncertainties, utilizing the commercial code CFX
  - Results to be summarized in a High Temperature Reactor 2014 conference paper on the overall progress status of Phase I
- Established second workshop of the OECD Nuclear Energy Agency's Benchmark for Prismatic Coupled Neutronics/Thermal Fluids Transient of the Modular High-Temperature Gas-Cooled Reactor 350 MW Core Design
  - June 23-26, 2014 at Idaho National Laboratory
- Developing experimental datasets that envelop the anticipated prismatic HTGR operational regime
- Verifying and validating assessment codes and simulation models for generic HTGR designs and computational benchmarks

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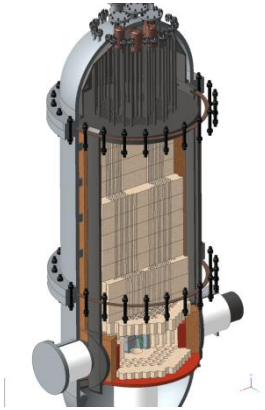
Passive Heat Removal System – Testing Activities

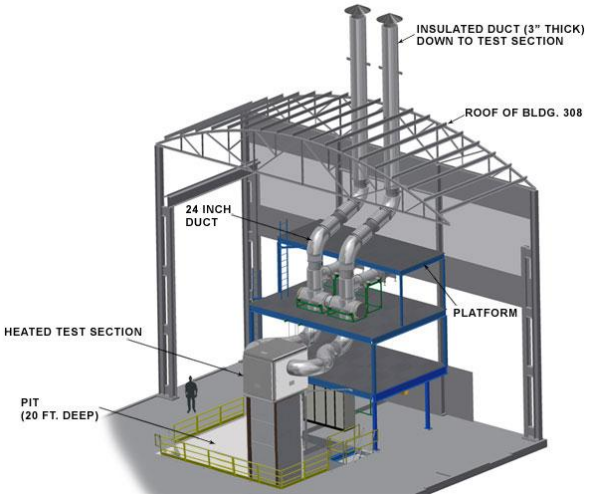
- The capability to remove reactor core residual heat by passive and inherent means is another key to the safety basis for the modular HTGR design concept.
- The NRC's Policy Statement on Advanced Reactors provides an expectation that advanced reactors will provide enhanced margins of safety, including use of:

  "Highly reliable and less complex shutdown and decay heat removal systems. The use of inherent or passive means to accomplish this objective is encouraged."

- The US Department of Energy is supporting the testing of passive heat removal systems and concepts:



  - Argonne National Laboratory
  - Oregon State University
  - Texas A&M University
  - University of Idaho
  - University of Wisconsin – Madison



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NRC-DOE Licensing Strategy – Report to Congress (2008)

NRC and Department of Energy (DOE) jointly agreed, rather than establishing a new set of regulations covering High Temperature Gas-Cooled Reactors (HTGRs), that:

"***The best approach to establish the licensing and safety basis for the NGNP will be to develop a risk-informed and performance-based technical approach that adapts existing NRC LWR technical licensing requirements in establishing NGNP design-specific technical licensing requirements***"

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Two Pronged Approach to Safety Design Criteria

1) Adaptation of LWR-based NRC 10CFR50 App A General Design Criteria (GDCs) to modular HTGRs
   - Joint initiative between DOE and NRC
   - Draft design criteria have been developed by DOE & National Laboratories
   - Review by reactor developers and end-users is in progress
   - DOE expects to issue a proposed set of criteria to NRC in November, 2014

2) Development of Principal Design Criteria (PDC) from a Risk-Informed Approach
   - Establish an approach to demonstrate how the functional statements from top level regulatory criteria are met for:
     - Mitigation of Design Basis Events
     - Prevention of Beyond Design Basis Events

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NRC Feedback on DOE's Proposed Risk-Informed Approach

- DOE has been engaged with the NRC for 4 years (2009 – 2013) in addressing priority NGNP licensing topics
  - White paper submittals from DOE/INL to NRC
  - Written responses to NRC requests for information
  - Numerous NRC public meetings
- NRC has completed a draft assessment, and concluded that the following approaches proposed by DOE are reasonable:
  - Establishment of event sequence frequencies
  - Assessment of integrated risk at multi-reactor module plant sites
  - Overall process for performing assessments against the top level regulatory criteria
  - Approach to risk-informed safety classification of structures, systems, and components

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NGNP Industry Alliance Limited

- Promoting the development and commercialization of High Temperature Gas-cooled Reactor (HTGR) technology
- HTGR – safe & reliable nuclear energy for industrial applications, reducing dependence on fossil fuels for high temperature heat resources

NEI Nuclear Energy Institute
American Nuclear Society
United States Nuclear Infrastructure Council
Dow
AREVA
Westinghouse
Toyo Tanso Inspiration for Innovation
SRS Community Reuse Organization two states, one future
ConocoPhillips
Entergy
US Ultra Safe Nuclear Technology
Technology Insights
Advanced Research Center
PTAC
Mersen
SGL Group The Carbon Company
GrafTech International
Wyoming Governor's Office
Manufacturing Excellence Consulting, Inc.
www.ngnpalliance.org

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NGNP Alliance Activities

Reports prepared for DOE in 2013

- HTGR Market, Risk and Sensitivity Analyses
- Impacts of HTGR Commercialization
- HTGR Commercialization Strategy
- Impacts from other Energy Sectors
- HTGR Siting Issues
- HTGRs for Liquid Fuels and Feedstock
- Industrial Integration
- HTGR Regulatory Risks

Activities conducted independently by NGNP Alliance

- Studies of Wyoming and Kentucky nuclear assisted CTL
- Canadian oil sands and Louisiana cogeneration siting studies
- Outreach to Kingdom of Saudi Arabia, Singapore, Indonesia, Thailand
- Collaborations: Japan, Korea, NC2I, StarCore

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US Path Forward

- Going forward, DOE will continue to support:
  - High priority research, including testing at scaled facilities, supporting modular HTGR safety case and licensing approach
  - International collaborations supporting HTGR technology
  - HTGR licensing framework development activities

- US supports this important CRP activity
  - Establish comprehensive process for development of safety design criteria
  - Integrate results and insights obtained from ongoing research supporting HTGR safety case
  - Build on US experience with NGNP, including positive initial response from NRC regarding DOE's proposed process for design criteria development