



Advanced Gas Reactor Fuel Development and Qualification Program

July 2021

Changing the World's Energy Future

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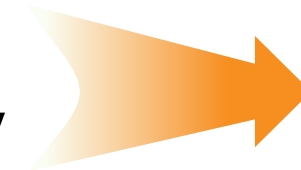
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Objectives and Motivation

- Provide data for fuel qualification in support of reactor licensing
- Establish a domestic commercial TRISO fuel fabrication capability

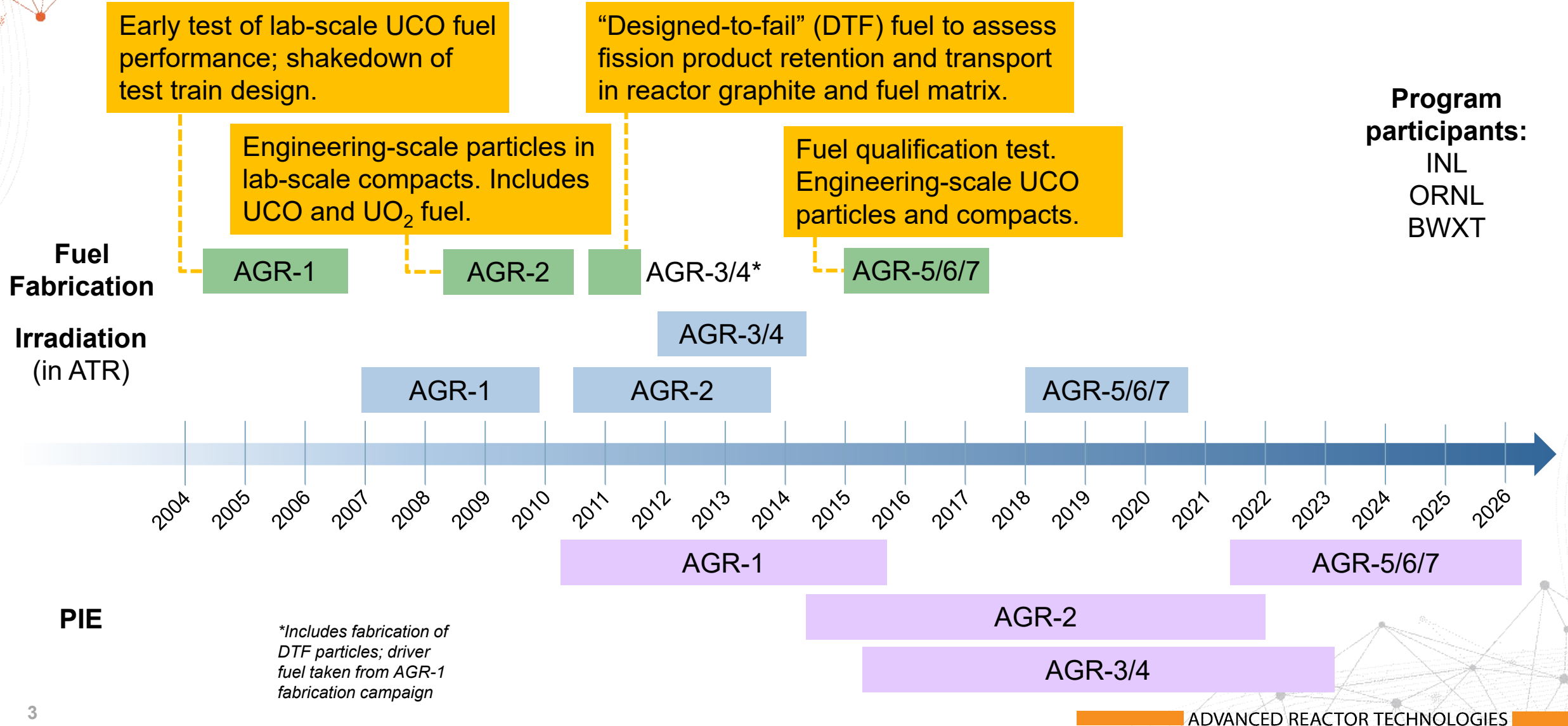


**Reduce market
entry risk**

Approach

- Focus is on developing and testing **UCO** TRISO fuel
 - **Develop fuel fabrication and quality control measurement methods**, first at lab scale and then at industrial scale
 - **Perform irradiation testing** over a range of conditions (burnup, temperature, fast neutron fluence)
 - **Perform post-irradiation examination and safety testing** to demonstrate and understand performance during irradiation and during accident conditions
 - **Develop fuel performance models** to better predict fuel behavior
 - **Perform fission product transport experiments** to improve understanding and refine models

AGR Program Timeline





Major Program Activities

AGR-2

- Final PIE report preparation (September 2021)
- Microanalysis of particles
- Oxidation testing of loose particles

AGR-3/4

- Radial deconsolidation and leach-burn-leach of fuel compacts
- Evaluation of fission product profile data and comparison with transport model



Major Program Activities (cont'd)

AGR-5/6/7

- Irradiation data analysis and reporting
- Post-irradiation examination preparation (equipment qualification and installation in hot cells)
- Nondestructive examination of the test train (gamma spectrometry, neutron radiography)
- Preparation of irradiated fuel oxidation testing capability (AMIX)

Fuel Performance Modeling

- AGR-5/6/7 as-run fuel performance predictions
- AGR-3/4 fission product transport modeling with BISON



Major Program Activities (cont'd)

Data Management

- Irradiation and PIE data analysis and qualification support

Other activities

- Disposition of excess material from fuel fabrication at BWXT continues and is nearing completion



Major Accomplishments – Last 12 Months

Fuel Fabrication

- Completed fuel fabrication materials disposition at ORNL

Irradiation

- Completed AGR-5/6/7 irradiation July 22, 2020
- Shipped experiment to MFC for PIE
- Issued numerous data analysis reports

Fuel Performance Modeling

- Issued PARFUME – BISON coated particle model comparison using AGR-2 irradiation experiment data (INL/EXT-20-59890)

Major Accomplishments – Last 12 Months (cont'd)

Post-irradiation Examination

- Completed microscopy study of irradiated AGR-2 fuel kernels (INL/EXT-21-62124)
- Issued report on AGR-2 loose particle heating tests to evaluate fission product release behavior (ORNL/TM-2020/1715)
- Completed destructive exams of AGR-3/4 graphite/matrix rings and construction of radial fission product profiles (INL/EXT-21-62863)
- Completed radial deconsolidation of 5 AGR-3/4 compacts
- Completed Phase 1 and 2 qualification for AGR-5/6/7 disassembly and capsule leaching equipment
- Completed NDE of AGR-5/6/7 Capsules 1 and 2

AGR Program Staffing Changes

- **Adriaan Riet** (INL) – AGR-3/4 data analysis and fission product transport modeling
- **Jillian Epstein** (INL) – Post-irradiation examination
- **Ryan Fronk** (INL) taking over responsibilities for fission gas measurement systems from **Dawn Scates**, who has taken a department manager position (Integrated Energy and Market Analysis Department)
- **Subhashish Meher** (INL) taking over responsibilities for TRISO advanced microscopy from **Isabella van Rooyen**, who is NTD for DOE Advanced Methods for Manufacturing (AMM) program at INL
- **Grant Helmrich** (ORNL) taking over responsibilities on AGR-3/4 destructive examinations from **John Hunn** at ORNL
- **Doug Marshall** (INL) to retire in Sep 2021

AGR Program Sponsored Publications – Last 12 Months

- 7 journal articles
- 8 conference proceedings
- 18 laboratory reports
- 8 invited presentations and lectures

P.A. Demkowicz, B.P. Collin, D.A. Petti, G.L. Hawkes, B.T. Pham, D.M. Scates, D.E. Stacey, J.W. Sterbentz, "AGR-2, the performance demonstration irradiation experiment of the Advanced Gas Reactor Fuel Development and Qualification Program," *Annals of Nuclear Energy*, 150 (2021) 107833

K.E. Wright, I.J. van Rooyen, "Fission product distribution in irradiated safety-tested and non-safety-tested AGR-2 TRISO particles," *IOP Conference Series: Materials Science and Engineering*, Vol 891, 012024, August 2020

T.J. Gerczak, R.L. Seibert, J.D. Hunn, C.A. Baldwin, F.C. Montgomery, R.N. Morris, "Redistribution of radionuclides in irradiated AGR-1 UCO TRISO fuel after 1800 °C safety testing," *J. Nucl. Mater.* 542 (2020) 152453

T.J. Gerczak, R. Seibert, J.D. Hunn, "Role of microstructure on CO corrosion of SiC layer in UO₂-TRISO fuel," *J. Nucl. Mater.* 537 (2020) 152185

T.J. Gerczak, J.D. Hunn, R.N. Morris, F.C. Montgomery, D.J. Skitt, C.A. Baldwin, J.A. Dyer, B.D. Eckhart, "Analysis of fission product distribution and composition in the TRISO layers of AGR-2 fuel," *Nucl. Eng. Des.* 364 (2020) 110656

P.A. Demkowicz, J.D. Hunn, "Two-Decade DOE Investment Lays Foundation for TRISO-Fueled Reactors in the US," *Nuclear News*, Vol. 63, August 2020

G.W. Helmreich, J.D. Hunn, J.W. McMurray, D.R. Brown, "Enhanced method for analysis of individual UCO kernel phase fractions," *Nucl. Eng. Des.* 363 (2020) 110625

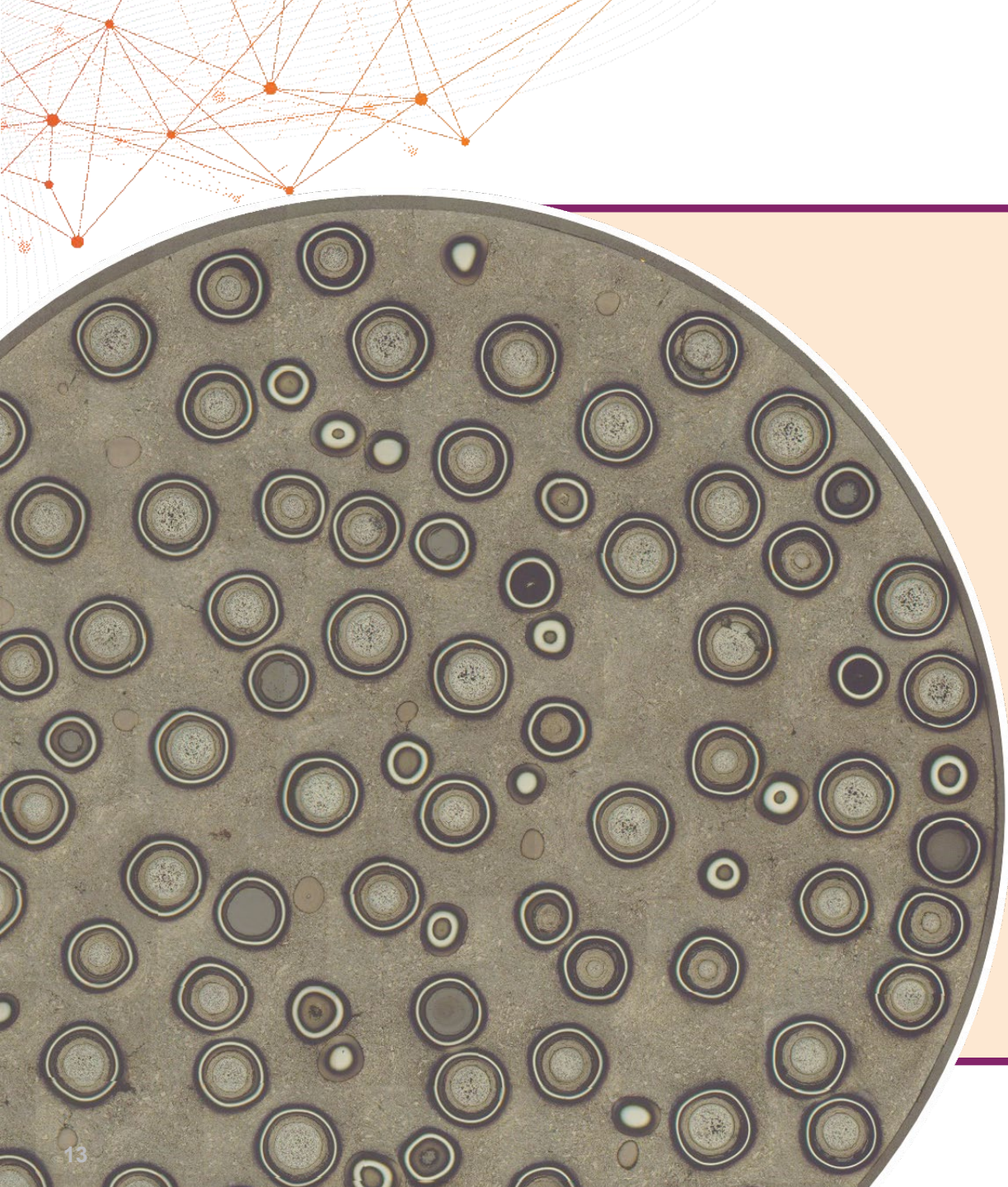
DOE-Funded TRISO-Fuel-Related Research Projects

Project ID	Lead Institution	Title
21-24111	Texas A&M University	Experimental Investigations of HTGR Fission Product Transport in Separate-effect Test Facilities Under Prototypical Conditions for Depressurization and Water-ingress Accidents
20-19556	University of Wisconsin-Madison	Statistical modeling of the effect of microstructural heterogeneity on the irradiation behavior of TRISO fuel buffer layer
20-19205	Missouri University of Science and Technology	Robust bullet-time tagging and tracking system based on computer vision for individual ex-core TRISO-fueled pebble identification
19-17251	Idaho State University	Measuring Mechanical Properties of Select Layers and Layer Interfaces of TRISO Particles via Micromachining and In-Microscope Tensile Testing
18-15171	Missouri University of Science and Technology	Oxidation behavior of silicon carbide and graphitic materials
18-15039	The University of Texas at San Antonio	Oxidation of Tristructural Isotropic fuel forms in low oxygen and steam partial pressures and the role of matrix burn off in the oxidation rate at high temperature
18-15097	Virginia Tech	Oxidation Study of High Temperature Gas-Cooled Reactor TRISO Fuels at Accidental Conditions
17-12710	University of Central Florida	Mechanisms of Retention and Transport of Fission Products in Virgin and Irradiated Nuclear Graphite
17-12830	University of Missouri-Columbia	Radioisotope Retention in Graphite and Graphitic Materials
16-10432	University of Michigan	Fission Product Transport in TRISO Fuel
16-10764	ORNL	Radiation Enhanced Diffusion of Ag, Ag-Pd, Eu and Sr in Neutron Irradiated PyC/SiC Diffusion Couples



Program Review Topics

- AGR-3/4 PIE activities
- AGR-3/4 fission product transport modeling
- Loose particle oxidation testing (AGR-2)
- ORNL irradiated particle microanalysis
- INL irradiated particle microanalysis
- AGR-5/6/7 irradiation results and reporting
- AGR-5/6/7 PIE: results and plans
- Future directions



Thank you for your attention

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