GAS-COOLED REACTOR

ADVANCED REACTOR TECHNOLOGIES PROGRAM

July 16, 2024

ART-GCR Program Overview

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National Technical Director: ART-GCR (INL)

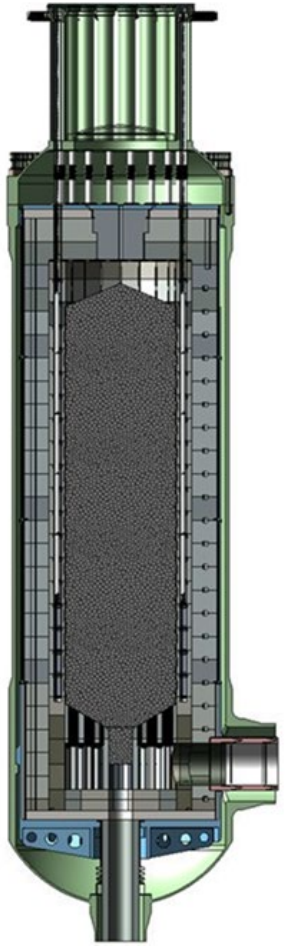
DOE ART GCR Review Meeting

Hybrid Meeting at INL

July 16–18, 2024

ART-GCR Program Review: Goals

- Provide overview of ART-GCR program objectives, status and activities.
- Identify research areas and outcomes that will benefit stakeholders and clients (HTGR designers, suppliers, regulators, DOE-NE, etc.).
- Identify remaining R&D gaps and future needs.



Why ART-GCR?

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- *"Why are you still doing research at the Labs, when we're building HTGRs already?"*
- *"Why does it take so long? Why is it so expensive to do work at the Labs?"*
- *"We need more focus on our near-term needs, not academic topics"*

The Point of What We Do

- It took more than 10 years to qualify and add Alloy 617 to the ASME code as a new high-temperature material for nuclear use. We started this in 2009.

- DOE supported graphite and TRISO fabrication, irradiation and PIE since 2002.

The Point of What We Do

- We have been building commercial LWRs for more than 60 years. Westinghouse, Framatome etc., still spend significant funds on fuel and materials R&D.

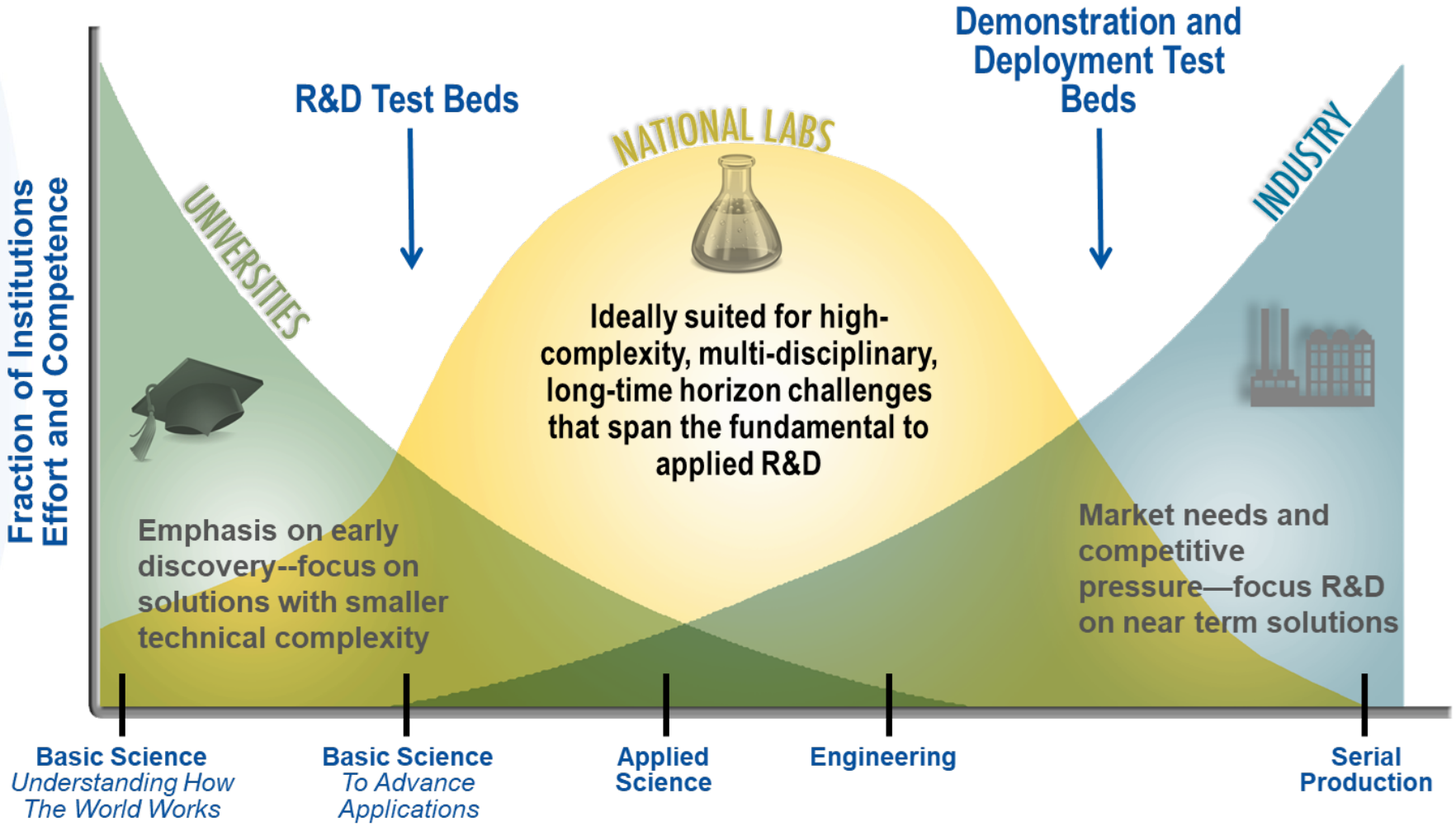
- National laboratories house very expensive and complex infrastructures: reactors, hot cells, highly-specialized and experienced staff, security, nuclear material handling, etc. Private industry cannot afford building and staffing this “backbone”.

The Point of What We Do

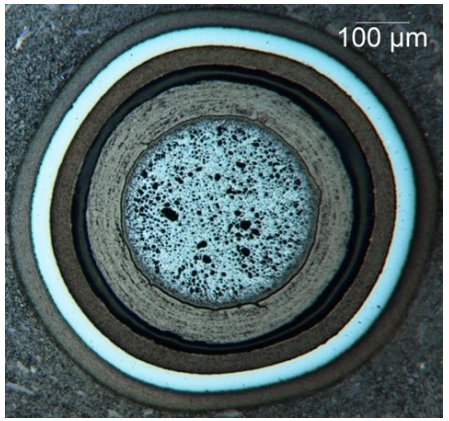
- DOE supports the “first-mover” front-end (HALEU supply, ARDP awards) and back-end (waste, decommissioning) aspects; both as a catalyst and a final custodian.

- We are asking the questions, anticipating the needs, and building the infrastructure to support industry and regulators with their needs that might only be realized years from now.

Short-Term vs Long-term Needs



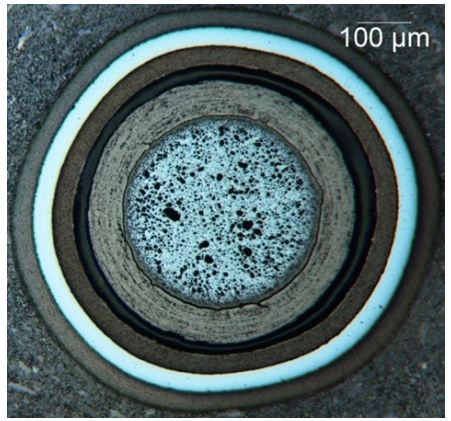
DOE ART-GCR Program Elements



Fuel development and qualification

- Generate UCO TRISO fuel performance data to support fuel qualification.
- Establish a domestic commercial TRISO fuel fabrication capability.

DOE ART-GCR Program Elements



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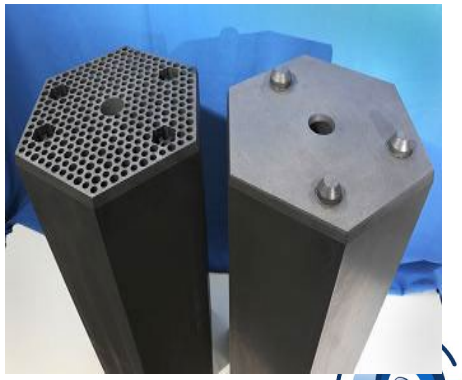
Graphite qualification

- Select, irradiate, and characterize existing nuclear grades.
- Qualify nuclear-grade graphite and establish design rules for use in HTGR cores.



DOE ART-GCR Program Elements

Advanced materials codification

- Achieve ASME codification of alloys and design methods for high-temperature use in pressure vessels, heat exchangers, and other primary circuit components.

Tensile Tests

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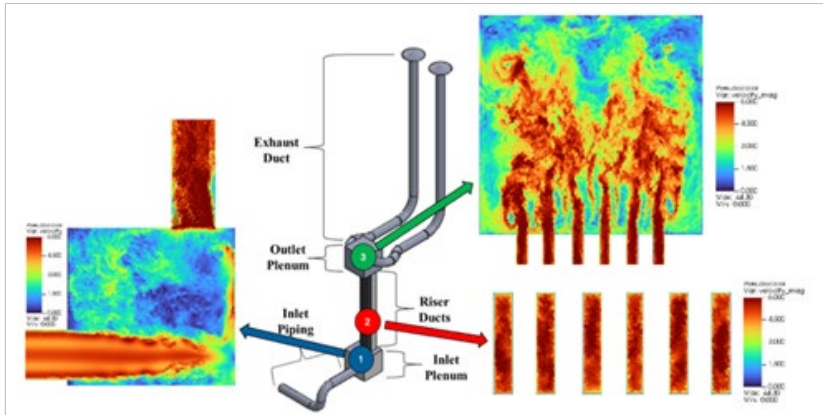
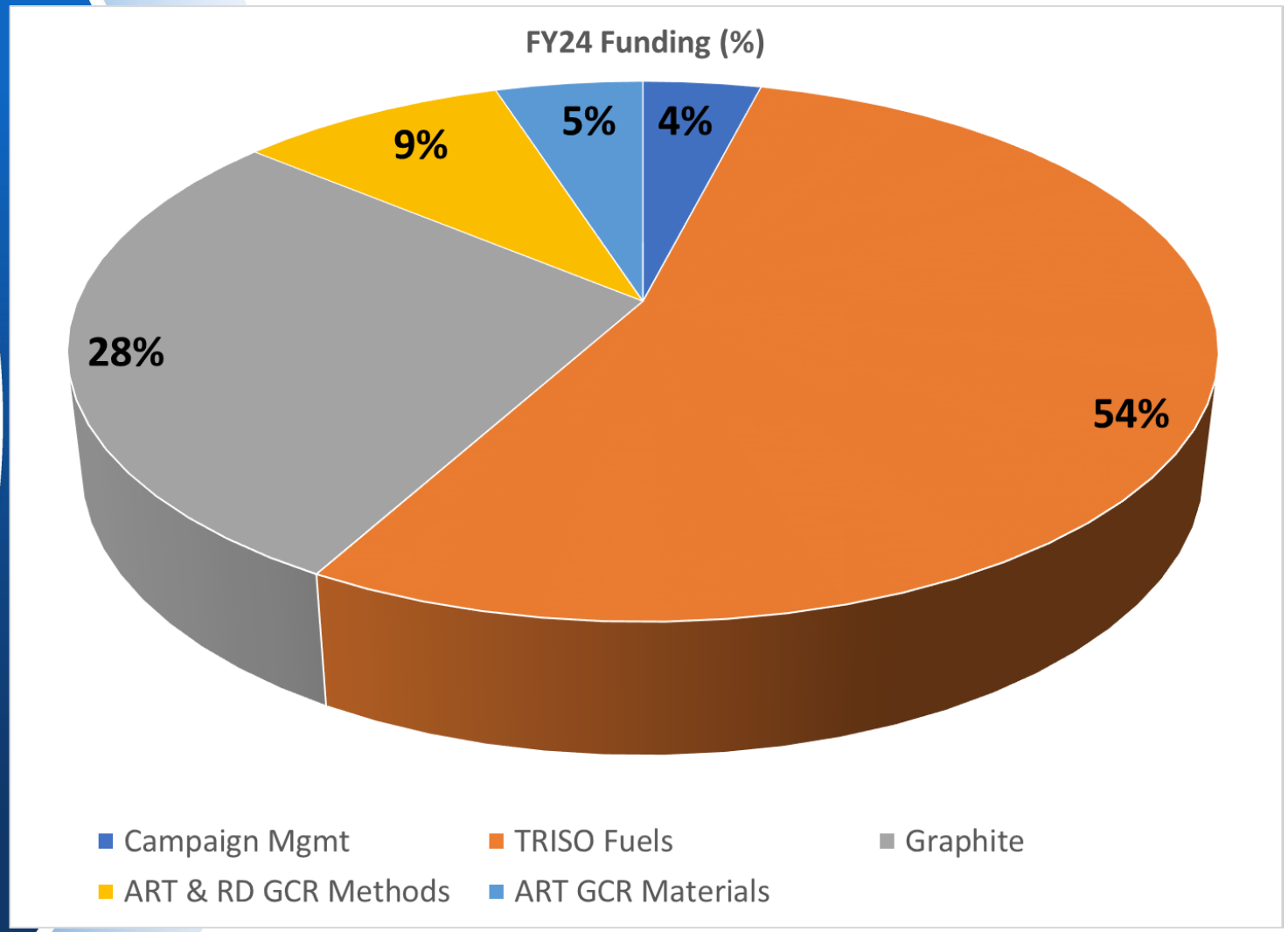
Tensile Tests

Experimental and simulation methods

- Develop prismatic and pebble bed HTGR core analysis methods
- Validate codes via experiments, code-to-code benchmarks, and uncertainty analyses.

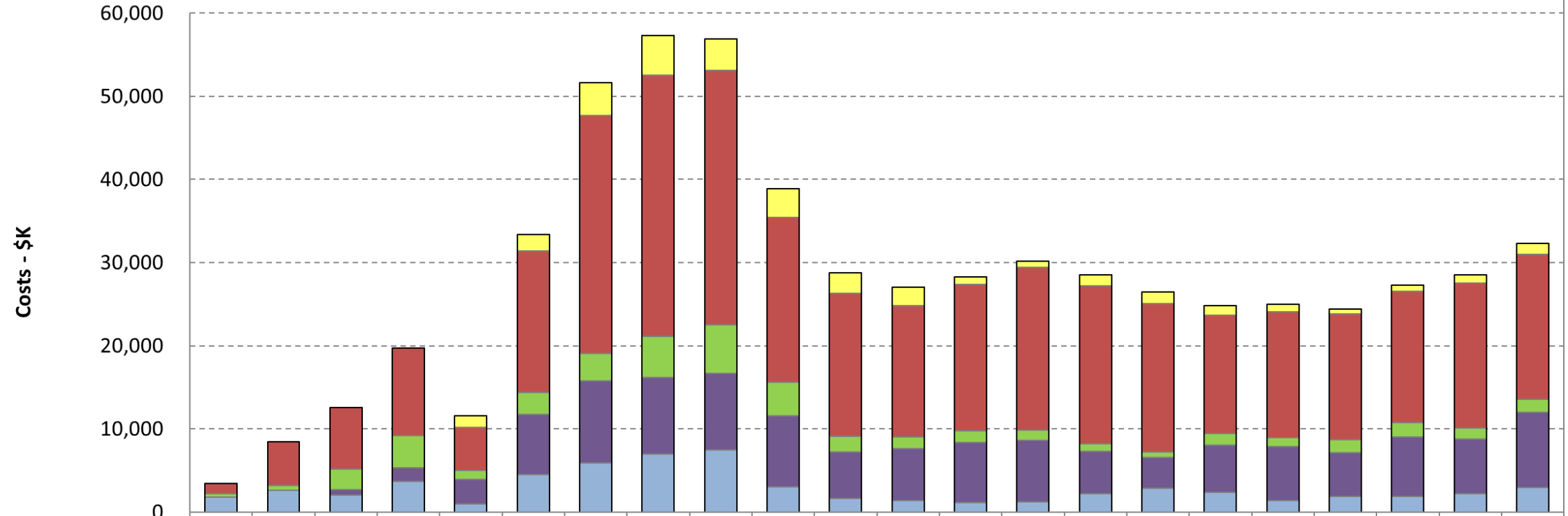


ART-GCR 2024 Funding Profile



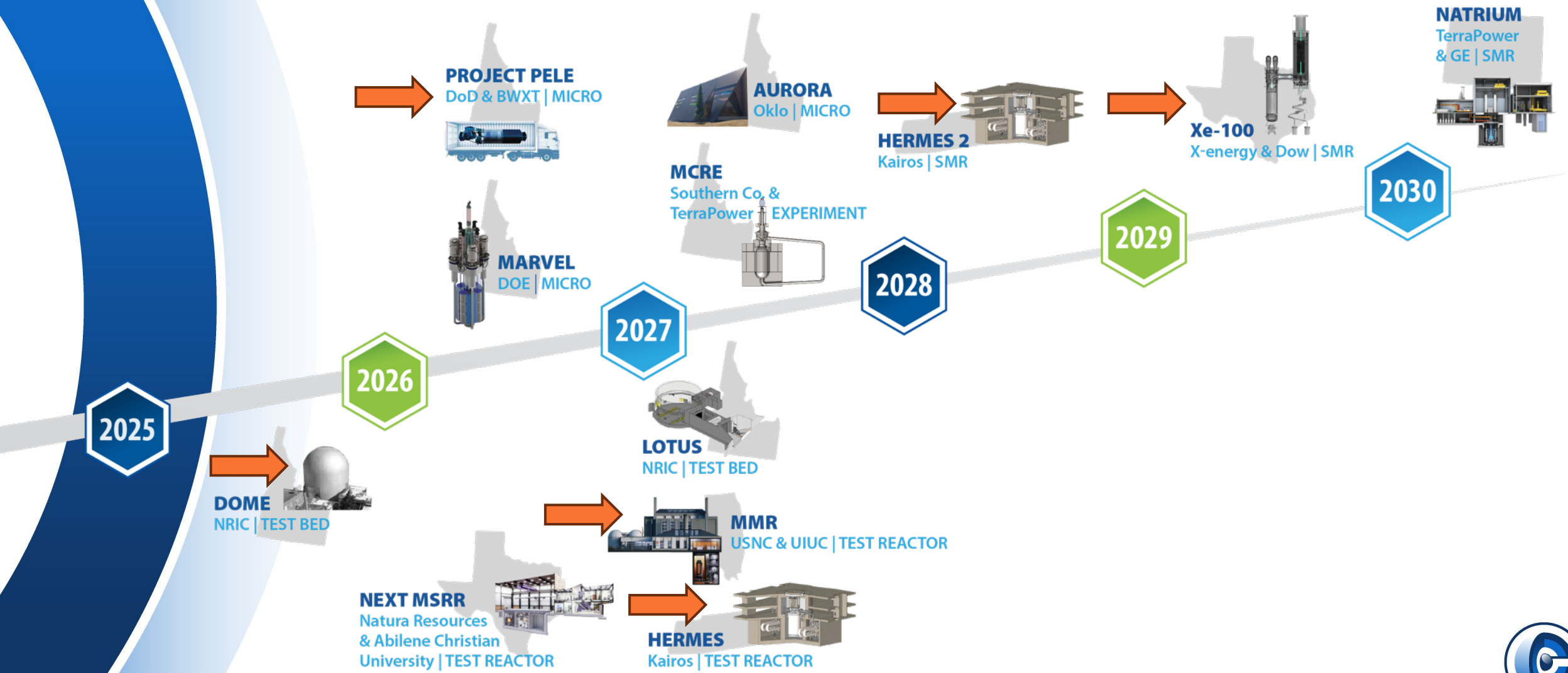
- ART-GCR is primarily a Fuel (54%), Graphite (28%) and High-Temperature Metals (5%) characterization and qualification program.
- Experimental and Core Simulation Methods component: 9%

21-Year DOE Investment in HTGRs: $625M

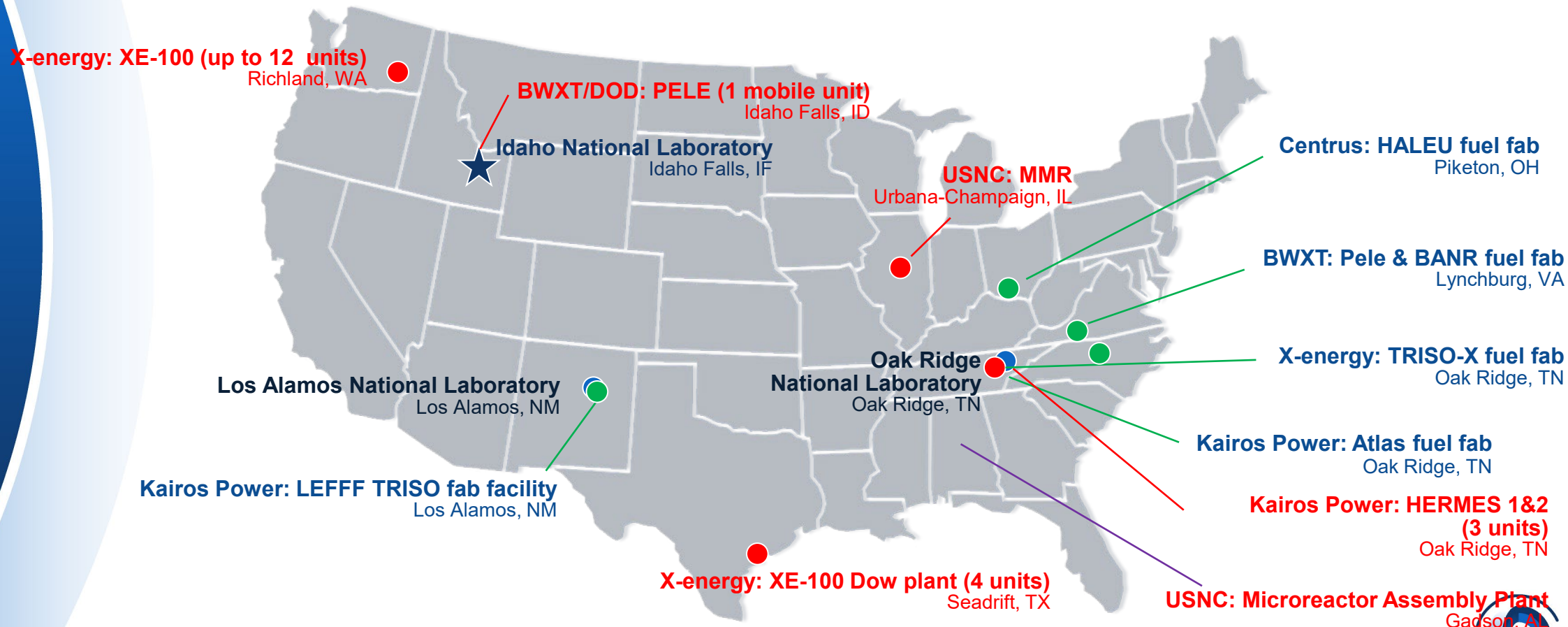


	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24*
TDO PM/Campaign Mgmt	0	0	0	0	1,404	1,952	3,903	4,727	3,812	3,460	2,473	2,252	940	751	1,265	1,431	1,149	863	545	771	983	1,280
Fuels	1,256	5,270	7,426	10,542	5,241	17,038	28,681	31,476	30,612	19,863	17,217	15,778	17,603	19,597	18,996	17,811	14,243	15,140	15,206	15,786	17,423	17,450
High Temp	334	576	2,487	3,886	1,040	2,663	3,248	4,931	5,777	4,035	1,934	1,375	1,370	1,278	912	705	1,386	1,074	1,515	1,727	1,277	1,600
Graphite	0	0	592	1,601	2,931	7,201	9,931	9,210	9,286	8,512	5,542	6,313	7,237	7,330	5,104	3,657	5,679	6,509	5,302	7,114	6,587	9,050
Methods	1,823	2,591	2,067	3,697	991	4,496	5,859	6,934	7,425	3,024	1,629	1,350	1,123	1,242	2,201	2,860	2,380	1,364	1,840	1,883	2,207	2,900
Total	3,413	8,437	12,572	19,726	11,607	33,350	51,622	57,278	56,912	38,894	28,795	27,068	28,273	30,198	28,478	26,464	24,837	24,950	24,408	27,281	28,477	32,280

USA Advanced Reactor Landscape

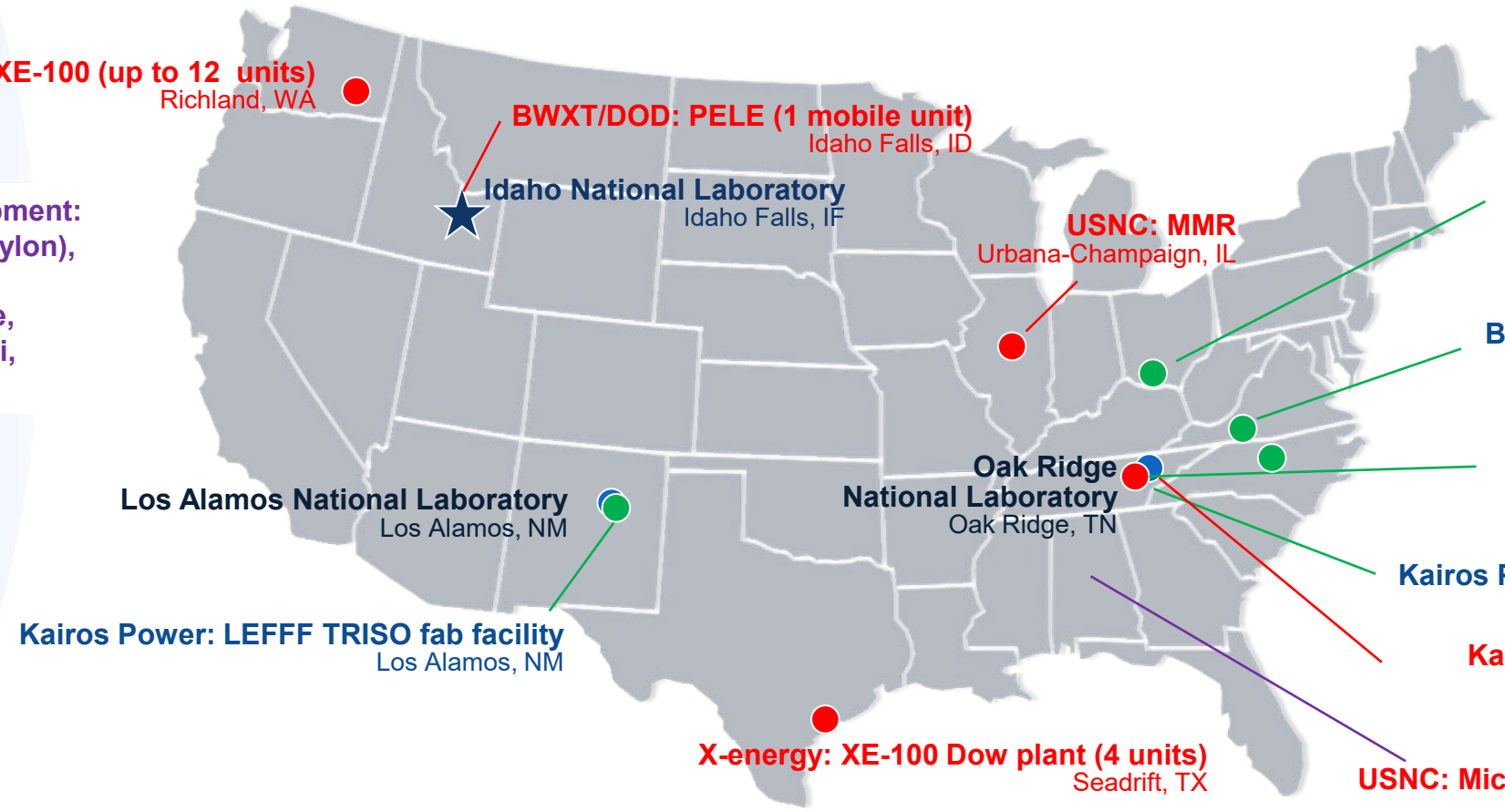


Commercial and Demonstration Projects: Planned Reactor and Fuel Fabrication Facilities



Commercial and Demonstration Projects: Planned Reactor and Fuel Fabrication Facilities

Microreactors under development: BWXT (Pele), USNC (MMR, Pylon), X-Energy (XENITH), Radiant Kaleidos, HolosGen, NuCube, NuGen, Westinghouse eVinci, Boston Atomics, etc.,…



Demonstration of Micro HTGRs in DOME

- **TRISO-fueled** Radiant, Ultra Safe Nuclear Corporation and Westinghouse microreactors have been awarded DOE funding for front-end engineering and experimental design.
- Will be housed in the Demonstration of Microreactor Experiments (*DOME*) facility at INL.

ART-GCR Future Outlook

- **TRISO**
  - Complete AGR-3/4 data analysis and AGR-5/6/7 PIE and safety testing, and compile AGR datasets for use by reactor designers
  - Assess future support of non-AGR coated particle fuel forms. Current AGR program and future scope moved to NE-4 in 2024, as part of Advanced Fuel Cycle (AFC) program.

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- **Graphite**
  - Complete high-dose graphite (HDG) experiments to provide baseline vs. irradiation performance data.
  - Continue ASME graphite codification efforts and salt-interaction assessments.

ART-GCR Future Outlook

- **Advanced Materials/Metallics**
  - Qualify and incorporate Alloy 709 into ASME Code as high temperature construction material for SFR, HTGR and MSR applications with 100,000 hour Code Case by end of 2024.
  - Develop and implement high temperature design *methodology* needed for advanced reactor designs into the ASME Code to improve and simplify the design process.

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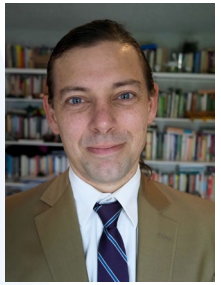
- **Core Simulation Methods**
  - Compare results for NEA HTTF benchmark to validate system and CFD codes.
  - Simulate all three HTTR LOFC transients as part of NEA benchmark
  - Prepare and perform Gen-IV international benchmark and validation activities.
  - NSTF at ANL: current water-based RCCS testing will end in FY25. Assessing future use of this facility (pebble bed or micro-reactor validation data support).

ART-GCR Leadership



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Metallics Lead

Courtney Otani (INL)
NDMAS and Gen-IV Handbook
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Thank You!

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U.S. DEPARTMENT OF ENERGY