GAIN

Gateway for Accelerated Innovation in Nuclear - What is it & is it helping?

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GAIN Gateway for Accelerated Innovation in Nuclear

INL Idaho National Laboratory

Oak Ridge National Laboratory

Argonne National Laboratory

INL/MIS-17-41148

What is the GAIN Initiative?
Gateway for Accelerated Innovation in Nuclear

What are the issues?

- Time to market is too long
- Facilities needed for RD&D are expensive
- Capabilities at government sites have not been easily accessible
- Technology readiness levels vary
- Some innovators require assistance with regulatory processes

What do we need to do?

- Provide nuclear innovators, **suppliers,** and investors with single point of access into DOE complex
- Provide focused research opportunities and dedicated industry engagement
- Remove barriers and make connections
- Accelerate joint work with NRC for advanced reactor licensing

What is the GAIN initiative?

- **A private-public partnership framework dedicated to rapid and cost-effective development of innovative nuclear energy technologies toward market readiness**

DOE recognizes the magnitude of the need, the associated sense of urgency and the benefits of a strong and agile private-public partnership in achieving the national leadership goals.

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Where is nuclear innovation needed?

Advanced Reactor Concepts (engineering, licensing, construction, advanced fuels/materials, modular designs, fuel cycle research, etc.)

Components (cables, materials, etc.)

Advanced Methods & Processes

Collaboration (vision driven, trust, learning, etc.)

Safety / Security (Cyber, digitization, control room mods, inspection techniques, passive safety features, etc.

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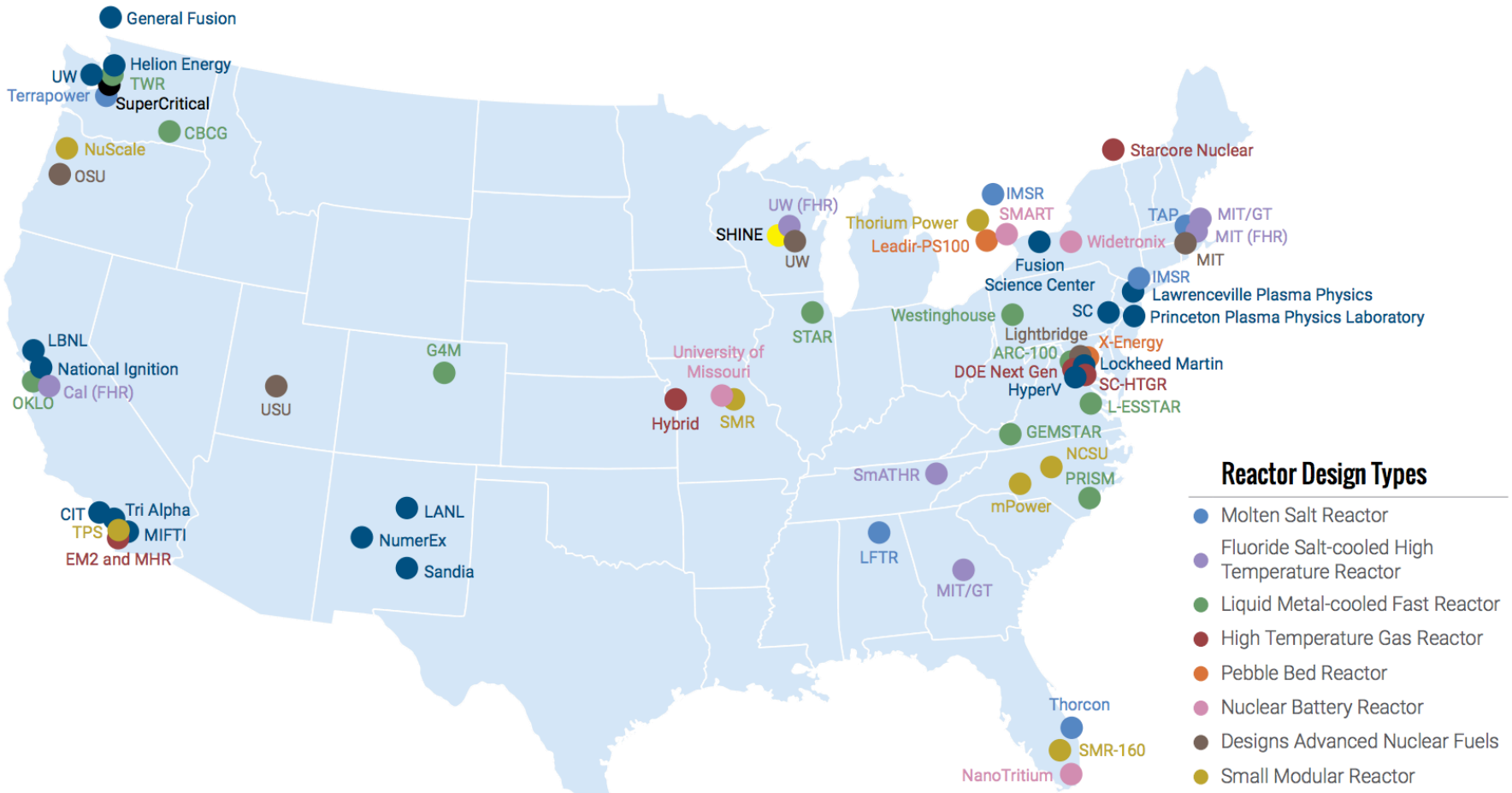
Advanced Nuclear Industry: Next Generation



Reactor Design Types

- Molten Salt Reactor
- Fluoride Salt-cooled High Temperature Reactor
- Liquid Metal-cooled Fast Reactor
- High Temperature Gas Reactor
- Pebble Bed Reactor
- Nuclear Battery Reactor
- Designs Advanced Nuclear Fuels
- Small Modular Reactor
- Fusion Reactor
- Super-Critical CO_2 Reactor
- Accelerator Driven System

third way
fresh thinking

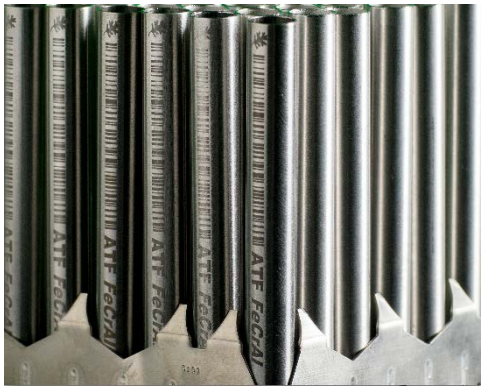
Vision / Mission

Vision (2030)

The U.S. nuclear industry is equipped to lead the world in development of innovative nuclear technologies to supply urgently needed abundant clean energy both domestically and globally.

Mission

Provide the nuclear energy industry with access to the technical, regulatory and financial support necessary to move innovative nuclear energy technologies toward *commercialization* in an accelerated and cost-effective fashion



New **accident tolerant fuel (ATF) cladding**, conceived, developed, manufactured, and tested at ORNL, has been manufactured by Global Nuclear Fuels (GNF) into lead test assemblies, and shipped to Southern Nuclear Operating Company for trials in Edwin I Hatch plant. The FeCrAl cladding, called IronClad (see figure), will be the first developed through DOE's Enhanced ATF program to be installed in a commercial nuclear reactor. (February 2018)

GAIN Initiative: Simultaneous Achievement of Three Strategic Goals

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GAIN: Connecting nuclear innovators to DOE laboratory capabilities and RD&D programs

Modeling & Simulation	Crosscutting Design Support	NRC Interface	Base Reactor and Fuel Cycle R&D Programs	Experimentation
HPC Infrastructure	Nuclear Hybrid Energy	Licensing Framework	Advanced Fuel Cycles	Nuclear Fuels
Verification and Validation	Nuclear Cyber Security	Gradual Risk Reduction	Advanced Reactors	Instrumentation and Sensors
M&S Expertise	Digital I&C Human Factors	Licensing Support Expertise	LW-based Reactors	Materials Science
Reactor physics				Test Reactors

Modeling and Simulation | **Expertise** | **Unique Facilities**

Knowledge Management & Integration

– GAIN –

Industry and investor access to DOE capabilities and expertise

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Collaboration is Essential

Industry-Led, Technology Working Groups (TWGs)

- Molten Salt Reactor
- Fast Reactor
- High Temperature Gas Reactor

Roles and Responsibilities

- **EPRI: Develop joint-strategies for V&V**
  - Stakeholders – advanced M&S cross-cutting tools
  - NRC – usage of advanced M&S tools for licensing analysis
- **NEI:** Facilitate/coordinate TWG activities with NEI's ARWG
  - Coordinate with GAIN and EPRI to support working groups
  - Work with industry, DOE, and NRC on issues associated with obtaining 5% < enriched uranium <20%
- **GAIN:** Integrate TWGs needs with DOE programs and resources
- **National Technical Directors (NTDs):** Provide expert guidance and research prioritization
- **NRC:** Communicate with the advanced reactor industry and, as appropriate, modernize NRC licensing processes and regulations (MOU with DOE)
- **US NIC:** Partner in developing Advanced Nuclear Directory

TECHNOLOGY WORKING GROUPS (TWG)

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Molten Salt Reactor	
Duke Energy	Charlotte, North Carolina
Elysium Industries	Boston, Massachusetts
Exelon Corporation	Chicago, Illinois
Flibe Energy, Inc.	Huntsville, Alabama
Southern Company	Birmingham, Alabama
TerraPower, LLC	Bellevue, Washington
Terrestrial Energy USA Ltd.	New York, New York
ThorCon USA	Stevenson, Washington
Transatomic Power Corporation	Cambridge, Massachusetts
High Temperature Gas Reactor	
Framatome, Inc.	Lynchburg, Virginia
BWX Technologies, Inc.	Lynchburg, Virginia
Duke Energy	Charlotte, North Carolina
Kairos Power	Oakland, California
StarCore Nuclear	Montreal, Canada
X-Energy, LLC	Greenbelt, Maryland
Fast Reactor	
Advanced Reactor Concepts, LLC	Chevy Chase, Maryland
Columbia Basin Consulting Group, LLC	Kennewick, Washington
Duke Energy	Charlotte, North Carolina
Elysium Industries	Boston, Massachusetts
Exelon Corporation	Chicago, Illinois
General Atomics	San Diego, California
General Electric-Hitachi	Wilmington, North Carolina
Hydromine, Inc.	New York City, New York
Oklo, Inc.	Sunnyvale, California
Southern Company	Birmingham, Alabama
TerraPower, LLC	Bellevue, Washington
Westinghouse Electric Co., LLC	Cranberry Township, Pennsylvania

Note: GAIN, DOE NTDs, EPRI and NEI participate in all of the TWG teams

GAIN Highlights

FY16

- **GAIN Initiative Announced at the White House (November 6, 2015)**
- NE Voucher Pilot Initiated
- Executive Advisory Committee (EAC) Chartered
- **Eight NE Voucher Awards**
- DOE-NRC Workshop on Advanced Reactors Licensing
- MSR/HTGR/FR Technology Workshops
- Standard CRADAs for NE-Vouchers

FY17

- "Applied Technology" Label Cancelled on New Documents
- DOE-NRC MOU for GAIN
- MSR/FR Legacy Documents on gain.inl.gov
- RELAP5-3D Single-use License
- **Fourteen NE Voucher Awards**
- ORNL MSR Workshop
- GAIN EPRI M&S Gap Analysis Workshop
- GAIN Fuel Safety Research Workshop
- NSUF-GAIN Thermal Hydraulics Workshop

FY18

- TREAT Restart (November 15, 2017)
- Quarterly NE Vouchers/Industry FOAs
- NEAMS Executive Advanced Reactor Industry Council (NEARIC) Chartered
- **Advanced Nuclear Directory Developed**
- TREXR Database (TREAT Documents)
- **Five NE Voucher Awards – 1st Round**
- NRC M&S tools coupled to MOOSE tools – Comprehensive Reactor Analysis Bundle
- NEAMS MSR Workshop
- **Enabling Advanced Reactors for the Market Symposium**

Activities to Date

GAIN Operations

- Established small, agile organization
- Issued GAIN Execution Plan
- Issued Technology Specific Workshops Summary Report
- Implemented Standard CRADAs for NE vouchers

GAIN Outreach

- Presented GAIN to multiple conferences/meetings to solicit input from stakeholders
- Organized 3 Technology Specific Workshops (with NEI and EPRI) to solicit input on private-sector R&D needs for DOE-NE R&D program
- Conducted 2 Modeling & Simulation workshops
  - Model for additional future workshops
- Conducted Fuel Safety Research Workshop
- Conducted NSUF-GAIN Thermal-Hydraulics Workshop

2016-2018:

100 Nuclear Technology Companies* Involved with GAIN

27 Companies participate in a Technology Working Group (TWG)	2016 NE Vouchers awarded to 8 companies, including 5 not in a TWG	2017 NE Vouchers awarded to 14 companies, including 9 not in a TWG	2018 NE Vouchers awarded to 5 companies, including 2 not in a TWG	57 Companies involved with GAIN not in a TWG or a NE Voucher recipient

**Developers/Suppliers/Utilities*

FY-18 Round 1 GAIN NE-Voucher Awardees

GAIN 2018 1st Round NE Voucher Recipient	Awarded Proposal	DOE award	Partner Facility
Oklo, Inc.	Accelerate Development of Industry-Relevant Features in Modern Simulation Tools	**$417,000**	Argonne National Lab, Idaho National Lab
Terrestrial Energy USA	Advancement of Instrumentation to Monitor IMSR® Core Temperature and Power Level	**$500,000**	Oak Ridge National Lab
ThorCon	Electroanalytical Sensors for Liquid Fueled Fluoride Molten Salt Reactor	**$400,000**	Argonne National Lab
Ubix Resources	Nuclear Grade Graphite Powder Feedstock Development	**$320,000**	Oak Ridge National Lab
Vega Wave Systems, Inc.	Radiation Testing for Nuclear Inspection Systems	**$130,000**	Argonne National Lab

GAIN NE Voucher Recipient	Title	Partner Facility
AMS Corp. Knoxville, TN	Radiation Aging of Nuclear Power Plant Components	ORNL
Columbia Basin Consulting Group LLC Kennewick, WA	Methodology for Meeting Containment System Principal Design Criteria for Heavy Metal Fast Reactor Systems	PNNL
DYNAC Systems LLC Del Mar, CA	Dynamic Natural Convection System	INL
Elysium Industries Clifton Park, NY	Synthesis of Molten Chloride Salt Fast Reactor Fuel Salt from Spent Nuclear Fuel	INL / ANL
Fauske & Associates LLC Burr Ridge, IL	Development of an Integrated Mechanistic Source Term Assessment Capability for Lead- and Sodium-Cooled Fast Reactors	ANL
GSE Systems Inc. Sykesville, MD	Human Factors Engineering for the Move to Digital Control Systems – Improved Strategies for Operations	INL
Kairos Power LLC Oakland, CA	NEAMS [Nuclear Energy Advanced Modeling and Simulation] Thermal-Fluids Test Stand for Fluoride-Salt-Cooled, High-Temperature Reactor Development	ANL / INL
MicroNuclear LLC Franklin, TN	Development of the Microscale Nuclear Battery Reactor System	INL
Muons Inc. Batavia, IL	Conversion of Light Water Reactor Spent Nuclear fuel to Fluoride Salt Fuel	ORNL
NuVision Engineering, Inc. Pittsburgh, PA	Evaluation of Power Fluidic Pumping Technology for Molten Salt Reactor Applications	ORNL
Oklo Inc. Sunnyvale, CA	Risk-Informed Mechanistic Source Term Calculations for a Compact Fast Reactor	SNL/ANL
SMR Inventec LLC Camden, NJ	Small Modular Reactor-160 Primary Flow Stability	ORNL
Terrestrial Energy USA Ltd. New York, NY	IMSR® [Integral Molten Salt Reactor] Fuel Salt Property Confirmation: Thermal conductivity and Viscosity	ANL
Transatomic Power Corporation Cambridge, MA	Fuel Salt Characterization	ANL

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FY 2017 GAIN Vouchers:

- 41 Letters of Intent
- 32 Voucher requests submitted
- 25 separate small businesses
- 9 “returnees”
- 16 new businesses compared to the 2016 pilot
- ~$4.2M awarded to 14 small businesses

Future Activities in 2018

Workshops:

- Digital Instrumentation & Controls at Argonne National Lab: June 5-6, 2018
- Advanced Manufacturing at Oak Ridge National Lab: ~Dec. 2018

Database/catalog:

- Develop a list of historical advanced-reactor documents to support knowledge transfer; facilitate access to key documents through OSTI
- Develop and initiate the process to appropriately remove AT designation on high priority documents requested by industry

Funding Opportunities:

- Industry-focused FOA and Vouchers awarded quarterly for 5 years

Challenge: Streamline contracting mechanisms

- Class patent waivers
- Extended IP protection

Industry Impact

"The GAIN program is a great example of recent efforts to enhance how industry can work with the national labs and DOE. In the past year, significant progress has been made through the GAIN program to advance [commercialization] efforts, and these will continue to expand."

Dr. Jake DeWitte, CEO, Oklo, Inc., Congressional Testimony (July 2017)

"There's a tremendous amount of knowledge, expertise, experience and equipment that sits at the national lab level. Making those resources available through a program like the GAIN program is very helpful. It makes sense for national labs, it makes sense for the private sector."

Mr. Simon Irish, CEO, Terrestrial Energy USA, Ltd., Bloomberg BNA (March 15, 2017)

"We're very grateful for the support of the DOE's GAIN initiative as we progress through our technology development process. The work we'll perform with Argonne will be of immense value to both Transatomic and the molten salt technology community as a whole, and the GAIN initiative makes it all possible for us."

Dr. Leslie Dewan, CEO, Transatomic Power Corporation (July 31, 2017)

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"The people who are crazy enough to think they can change the world are the ones who do."

- Steve Jobs

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