

ARGONNE NUCLEAR ENERGY PROGRAM OVERVIEW



TEMITOPE TAIWO

Argonne National Laboratory
Nuclear Science and Engineering Division
May 2026

BIRTHPLACE OF NUCLEAR ENERGY



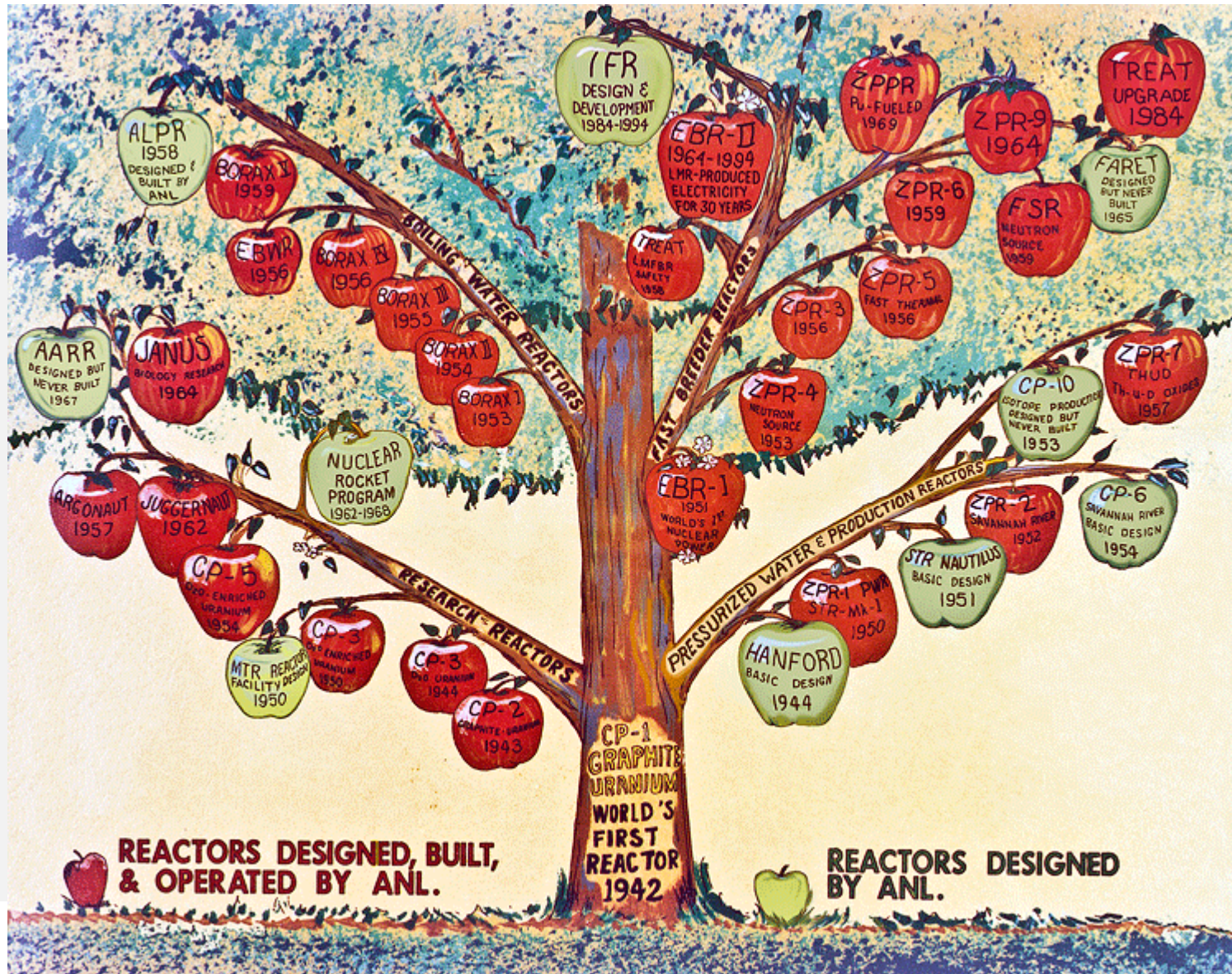
The world's first controlled-nuclear chain reaction was demonstrated by Fermi's team at the University of Chicago on Dec. 2, 1942. Operations moved to nearby "Argonne Lab" named after the surrounding forest.



The first demonstration of usable nuclear electricity: four light bulbs were lit on December 20, 1951, with electricity generated by EBR-1, the world's first LMFBF designed by Walter Zinn's team at Argonne.

- Argonne's heritage dates back to **Enrico Fermi** and the first controlled chain reaction (CP-1)
- Argonne pioneered thermal and fast reactors, as well as fuel recycling technologies
- Our work forms the foundation for commercial reactors in use worldwide, and future advanced reactors to come
- Argonne continues to advance the science and technology foundations for nuclear energy
- Nuclear energy expertise also applied to advance other Argonne Initiatives

ARONNE DESIGNED AND/OR OPERATED REACTORS



Reactors in Recent Times:

- ARC reactor collaboration
- Research reactor conversion projects
- Sodium & Xe-100 collaborations
- VTR collaboration
- PGSFR (KAERI) collaboration
- Advanced Burner Reactors
- SMFR (CEA, JAEA) collaboration
- SAFR (Rockwell) and PRISM (GE) Collaborations
- Many other reactor types

We deliver impact across the continuum from discovery science to technology deployment

PHYSICAL SCIENCES AND ENGINEERING

- Chemical sciences and engineering
- Materials science
- Nanoscience and technology
- Nuclear and particle physics

COMPUTING, ENVIRONMENTAL AND LIFE SCIENCES

- Biological and environmental science
- Computational science
- Data science and learning
- Mathematics and computer science

PHOTON SCIENCES

- Accelerator systems
- X-ray science

ADVANCED ENERGY TECHNOLOGIES

- Applied materials
- Energy systems and infrastructure analysis
- Transportation and power systems

NUCLEAR TECHNOLOGIES AND NATIONAL SECURITY

- Chemical and fuel cycle technologies
- Decision and infrastructure sciences
- Nuclear science and engineering
- Strategic security sciences

SCIENCE AND TECHNOLOGY PARTNERSHIPS AND OUTREACH

- Academic and industrial partnerships
- Community STEM engagement
- Entrepreneurship programs
- Technology commercialization

Argonne R&D Divisions

ARGONNE'S RESEARCH INTERESTS

NUCLEAR &
PARTICLE
PHYSICS

TRANSPORTATION
& COMBUSTION

PROTEIN
CHARACTERIZATION

IMAGING

NANOMATERIALS

ENERGY SYSTEMS
ANALYSIS

CHEMICAL
ENGINEERING

CHEMISTRY

MATERIALS
FOR ENERGY

GLOBAL
SECURITY

OIL AND GAS
INFRASTRUCTURE
ANALYSIS

ACCELERATOR
TECHNOLOGY

ENERGY STORAGE

NUCLEAR
ENERGY

HIGH-PERFORMANCE
COMPUTING

BIOLOGY &
ENVIRONMENT

MOLECULAR
ENGINEERING

COMPUTATIONAL
SCIENCE

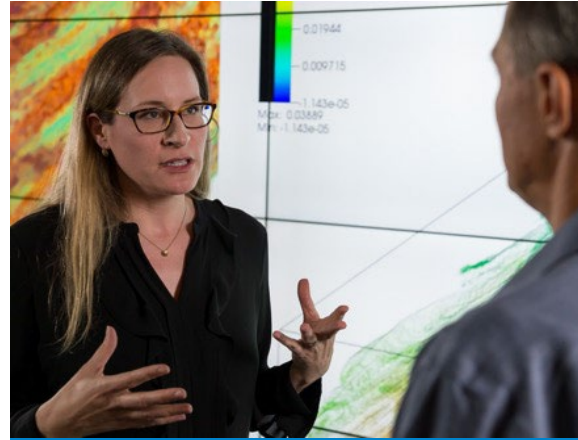
BIG
DATA

ADVANCED NUCLEAR ENERGY RESEARCH



Reactor R&D

Design and evaluation of research reactors and next-gen fission reactors cooled by molten metals, molten salt, or gas



Modeling & Simulation

High-fidelity analysis of reactor processes, leveraging Argonne's supercomputers



Fuel Cycle R&D

New ways to recycle fuel materials for energy production and reduce waste generation



Nonproliferation R&D

Develop technologies and approaches to safeguards and security for advanced reactors and associated facilities

GROUNDING IN DEEP EXPERTISE AND EXCEPTIONAL EXPERIMENTAL FACILITIES

DIVISIONS COMPRISING OUR PRIMARY NUCLEAR CAPABILITIES

Nuclear Science and Engineering (NSE)

- Nuclear Systems Analysis
- Research & Test Reactor
- Safety & Engineering Analysis
- Plant Analysis, Control, & Sensor
- Reactor Safety & Materials Testing

Chemical and Fuel Cycle Technologies (CFCT)

- Radiochemistry
- Pyroprocess & Material Development
- Fuel Development & Qualification
- Process Simulation & Safeguards
- Analytical Chemistry Lab

Strategic Security Sciences (SSS)

- NonProliferation Research Analysis and Engagement
- CBRN Detection and Analysis
- National and Cyber Security Information Sciences

ARGONNE CURRENT ONE-OF-A-KIND FACILITIES

Enabling science from nanoscale to exascale

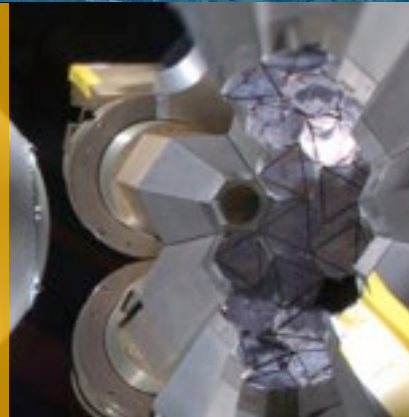
Advanced
Photon
Source

APS



Argonne
Tandem
Linear
Accelerator
System

ATLAS



Argonne
Leadership
Computing
Facility

ALCF



Center for
Nanoscale
Materials

CNM



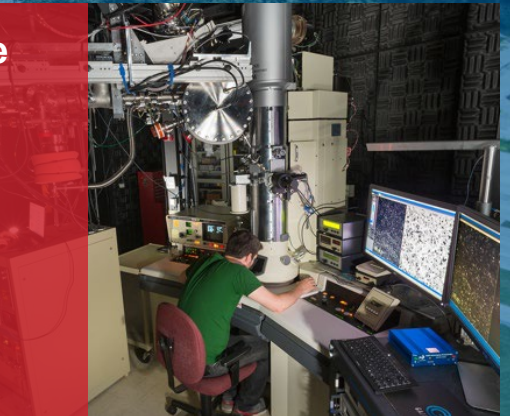
Atmospheric
Radiation
Measurement –
The Southern
Great Plains
and third ARM
mobile facility

ARM



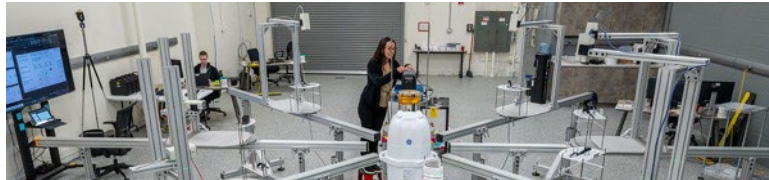
Intermediate
Voltage
Electron
Microscope

IVEM



NUCLEAR AND SECURITY RESEARCH FACILITIES

20+ facilities driving U.S. prosperity and security



Detection and Analysis Center (DAC)

Premier facility for testing and evaluation of radiological and nuclear detection equipment.



Mechanisms Engineering Test Loop (METL)

Dedicated development site of next-generation components and workforce for sodium fast reactors.



Thermophysical Properties Lab (TPL)

Extensive inert atmosphere gloveboxes and supporting equipment for molten salt chemistry and process development.



Low-Energy Accelerator Facility (LEAF)

Accelerator producing a range of radioisotopes for medical, national security, basic science and industrial applications.



Pyroprocessing Facility

Pilot-scale facility for demo of pyroprocessing technologies for recycling used nuclear fuels at scales relevant to industrial operation.



Activated Materials Laboratory (AML)

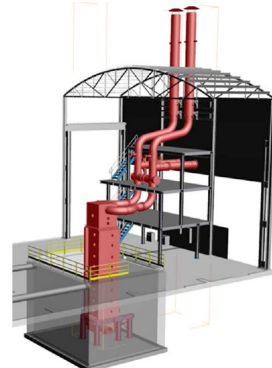
World-class support for nuclear community to examine radioactive samples at the High-Energy X-ray Microscope & other beamlines at the APS.

SAFETY-FOCUSED NUCLEAR ENERGY FACILITIES

From fabrication process development, through effects of irradiation on materials, to consequences of postulated accidents, **Argonne's experts apply remarkable infrastructures to improve reliability and resilience.**



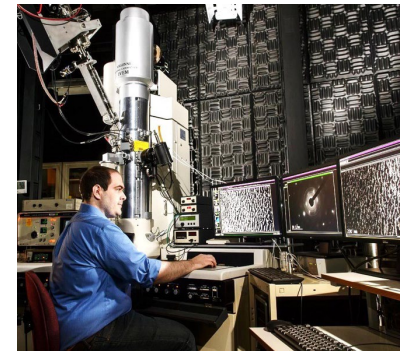
Irradiated Materials Laboratory



Natural Convection Shutdown Heat Removal Test Facility



LWR Melt Coolability and Concrete Interactions (MCCI) Facility for severe accident experiments



Intermediate Voltage Electron Microscopy (IVEM)-Tandem Facility: *In situ* study of radiation damage of nuclear materials and fuels



Pressure drop Experimental Loop for Investigations of Core Assemblies in advanced Nuclear (PELICAN)



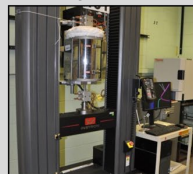
Environmentally Assisted Cracking



Corrosion Fatigue



Fatigue/Creep-Fatigue



High-temperature Tensile

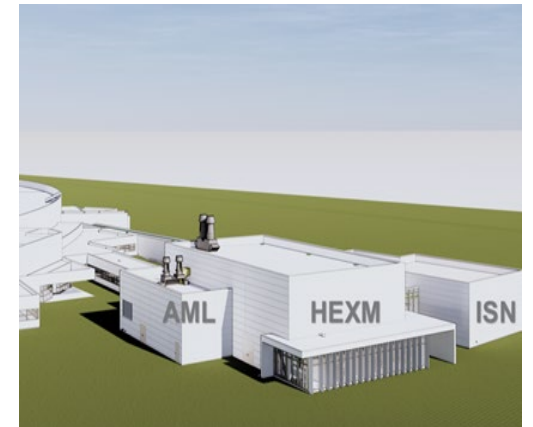


Creep Tests



Environmental Creep

Mechanical and Environmental Testing Laboratory (METLab)

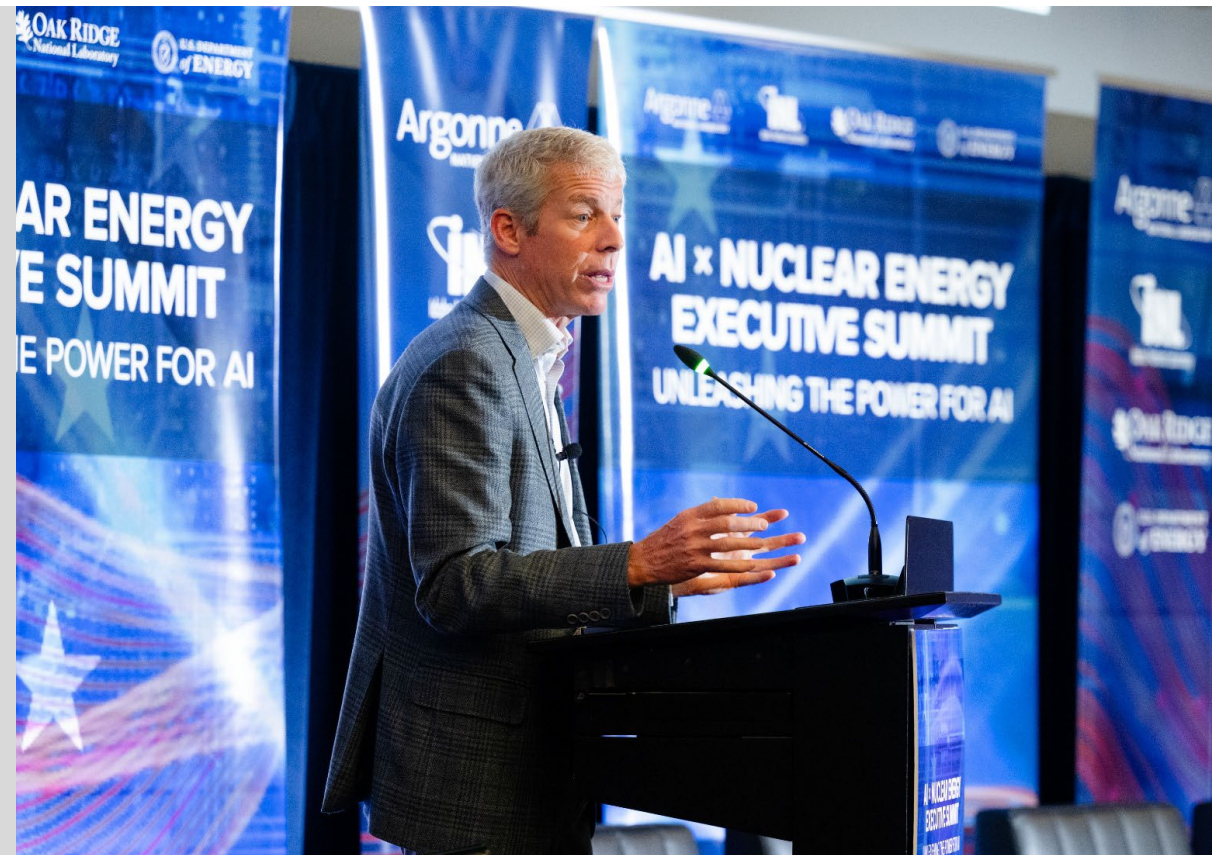


Activated Materials Lab (AML) coming soon at the APS

Argonne has strong foundational positioning...

For (another) U.S. nuclear energy revival

- **Recognized technical leadership**—International leaders in advanced and research reactor systems, and recycling
- **Broad industry engagement**—Currently working with nearly every viable reactor vendor in U.S. & many energy suppliers
- **International partnerships**—IAEA, OECD/NEA, Japan, Korea, UK, France, Canada, Ukraine and many others on 6 continents
- **Interdisciplinary expertise**—operating at intersection of nuclear energy and materials expertise, nonproliferation, economic security, AI and HPC
- **Key infrastructure**—SC user facilities and 20+ labs and facilities dedicated to nuclear energy



ARGONNE GAIN AWARDS BY THE NUMBERS

A strong GAIN collaborator since 2016 in reactor and fuel cycle work

- **Total awards: 37**
 - Completed: 30
 - Pending: 7 (6 and 1 cancelled)
- **Work types represented: 11**
- **Reactor types supported: 5**
- **Unique industry partners: 26**
- **Reactor types:** MSR (15), Liquid Metal (10), HTGR (2), LWR (2) & Multi (8)
- **Work types:** Modeling and Simulation; Material Properties; Experimental Testing; Material Testing; Thermal Hydraulic Testing; Irradiation and Testing; Manufacturing; Design; Safeguards; Fuel Cycle; Licensing
- **Industry Partners:** Aalo Atomics; Alpha Tech Research Corp; ARC Clean Technology; BGTL; CompRex; Elysium Industries; Energy Northwest; Fauske & Associates; Flibe Energy; Framatome; General Electric Hitachi Nuclear Energy; Global Nuclear Fuel; Hayward Tyler; HolosGen; Kairos Power; Moltex Energy; NuCube Energy; Oklo; Radiant Industries; SHINE Technologies; TerraPower; Terrestrial Energy; ThorCon; Transatomic Power; Vega Wave Systems; Zeno Power Systems

Argonne's support spans a diverse industry base and a wide range of reactor technologies

LEARN MORE ABOUT OUR WORK...

Argonne web page:

<https://www.anl.gov>

Nuclear Science and Engineering Division web page:

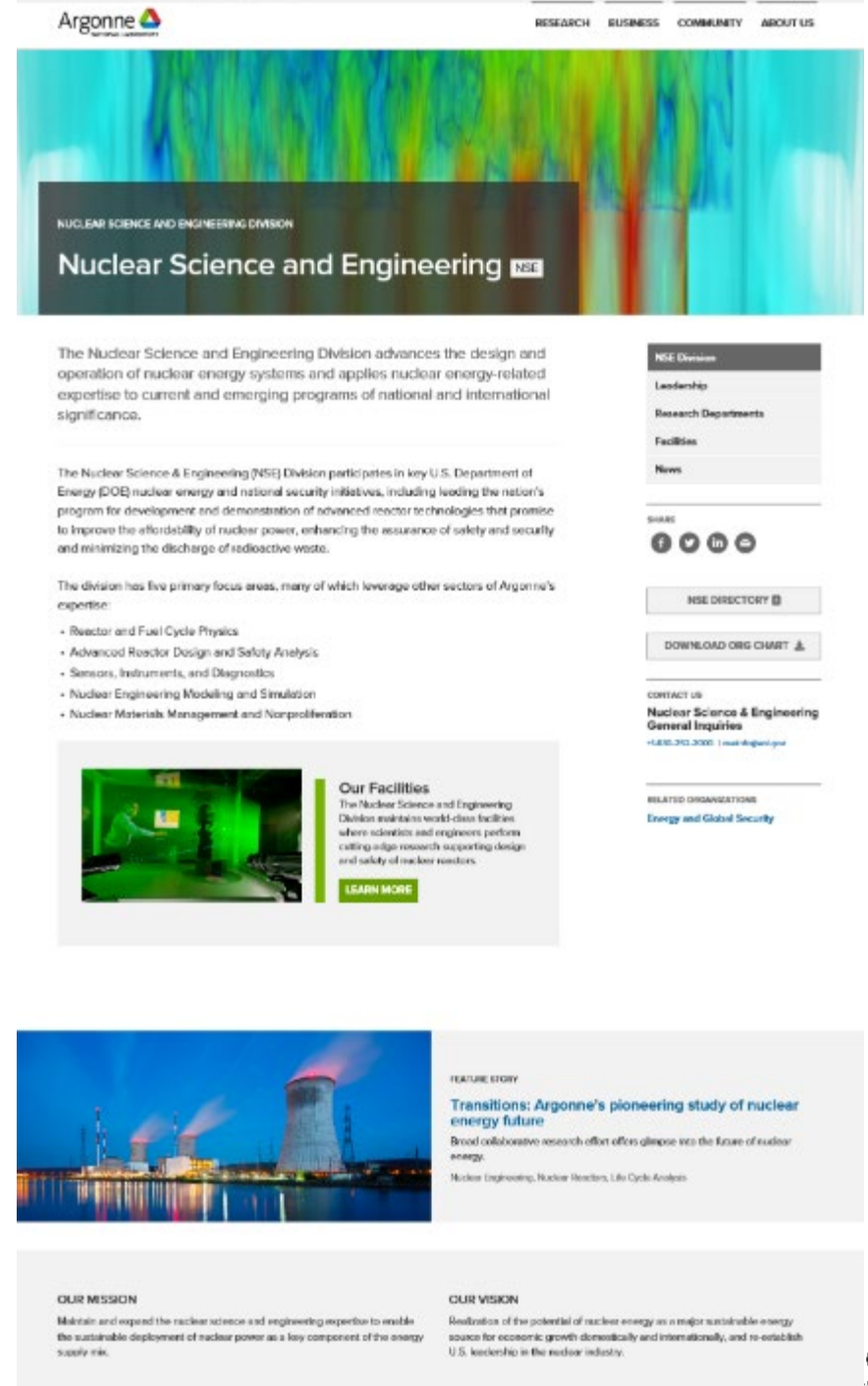
<https://www.anl.gov/nse>

Chemical and Fuel Cycle Technologies Division web page:

<https://www.anl.gov/cfc>

Strategic Security Sciences Division web page:

<https://www.anl.gov/sss>



The screenshot shows the Argonne National Laboratory website for the Nuclear Science and Engineering Division. At the top, the Argonne logo is on the left, and navigation links for RESEARCH, BUSINESS, COMMUNITY, and ABOUT US are on the right. The main header features a colorful abstract image and the text "NUCLEAR SCIENCE AND ENGINEERING DIVISION" and "Nuclear Science and Engineering NSE". Below this, a paragraph describes the division's mission: "The Nuclear Science and Engineering Division advances the design and operation of nuclear energy systems and applies nuclear energy-related expertise to current and emerging programs of national and international significance." A second paragraph states: "The Nuclear Science & Engineering (NSE) Division participates in key U.S. Department of Energy (DOE) nuclear energy and national security initiatives, including leading the nation's program for development and demonstration of advanced reactor technologies that promise to improve the affordability of nuclear power, enhancing the assurance of safety and security and minimizing the discharge of radioactive waste." A third paragraph lists five primary focus areas: "The division has five primary focus areas, many of which leverage other sectors of Argonne's expertise: • Reactor and Fuel Cycle Physics • Advanced Reactor Design and Safety Analysis • Sensors, Instruments, and Diagnostics • Nuclear Engineering Modeling and Simulation • Nuclear Materials, Management and Nonproliferation". Below this is a section titled "Our Facilities" with a photo of a reactor interior and a "LEARN MORE" button. The text reads: "The Nuclear Science and Engineering Division maintains world-class facilities where scientists and engineers perform cutting-edge research supporting design and safety of nuclear reactors." On the right side, there is a sidebar with a menu: "NSE Division", "Leadership", "Research Departments", "Facilities", "News", and "SHARE" with social media icons. Below the menu are buttons for "NSE DIRECTORY" and "DOWNLOAD ORG CHART". At the bottom right, there is a "CONTACT US" section for "Nuclear Science & Engineering General Inquiries" with a phone number and email address. A "RELATED ORGANIZATIONS" section lists "Energy and Global Security". At the bottom of the page, there are two columns: "OUR MISSION" and "OUR VISION". The mission statement is: "Maintain and expand the nuclear science and engineering expertise to enable the sustainable deployment of nuclear power as a key component of the energy supply mix." The vision statement is: "Realization of the potential of nuclear energy as a major sustainable energy source for economic growth domestically and internationally, and re-establish U.S. leadership in the nuclear industry." A "FEATURE STORY" section is also visible, titled "Transitions: Argonne's pioneering study of nuclear energy future" with a sub-headline "Broad collaborative research effort offers glimpse into the future of nuclear energy" and a link to "Nuclear Engineering, Nuclear Reactors, Life Cycle Analysis".

BACKUP SLIDES

Argonne Supporting U.S. Advanced Reactor Programs

ARDP goal: Demonstrate 2 reactor designs by end of 2020s

DEMONSTRATION

GOAL: Test, license and build operational reactors within 5 - 7 years.

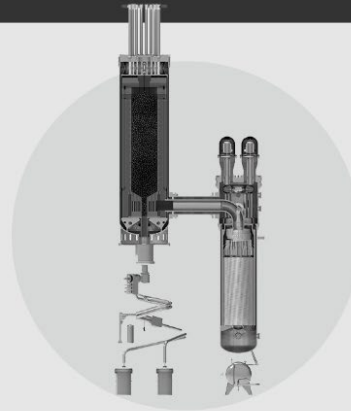


Natrium Reactor

Sodium-cooled fast reactor + molten salt energy storage system

TERRAPOWER

Natrium, in Kemmerer, Wyoming: 345-MW reactor coupled with 500-MW thermal energy storage for flexible electricity output when combined with renewable energy sources



Xe-100

High-temperature gas reactor

X-ENERGY

Xe-100, in Texas and Washington : Plant with four 76-MW reactor units to provide flexible electricity output and process heat for industrial applications

Argonne support to TerraPower

- Design: Core restraint system, instrumentation and controls
- Licensing: Software quality assurance, safety analysis, validation, and fuel qualification

Argonne support to X-Energy

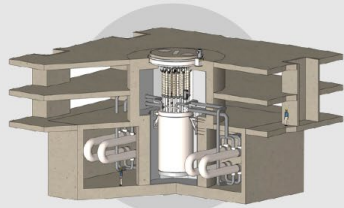
- Design verification to assist licensing and operations
- Applying computational fluid dynamics analyses of the core, reactor components, and steam generator

Argonne Supporting U.S. Advanced Reactor Programs

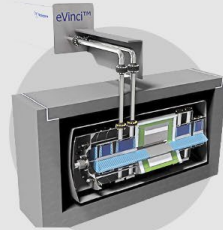
ARDP also supports risk reduction and concept development for 8 more reactor designs

RISK REDUCTION

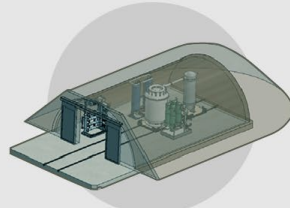
GOAL: Solve technical, operational and regulatory challenges to support demonstration within 10 - 14 years.



KP-FHR
Fluoride salt-cooled
high-temperature reactor
KAIIROS POWER



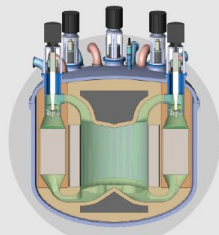
eVinci
Heat pipe-cooled
microreactor
WESTINGHOUSE NUCLEAR



BWXT Advanced Nuclear Reactor (BANR)
High-temperature
gas-cooled microreactor
BWX TECHNOLOGIES



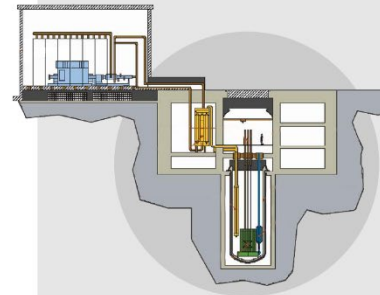
SMR-160
Advanced light-water
small modular reactor
HOLTEC INTERNATIONAL



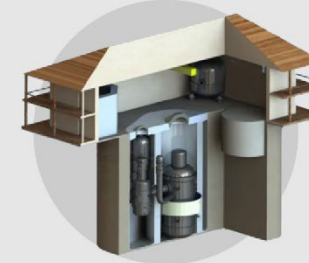
Molten Chloride Fast Reactor
SOUTHERN COMPANY

CONCEPT DEVELOPMENT

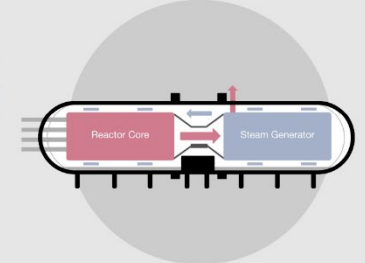
GOAL: Solidify concept to mature technology for potential demonstration by mid-2030s.



Advanced Sodium-Cooled Reactor Facility
ADVANCED REACTOR CONCEPTS



Fast Modular Reactor
GENERAL ATOMICS



Horizontal Compact High-Temperature Gas Reactor
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Argonne is a member of all 3 concept development teams and collaborates, through other DOE initiatives, with 4 of the risk-reduction participants

Other advanced reactors are under development by Oklo Inc, Westinghouse, DOD/SCO, etc.

SPONSORS AND COLLABORATORS (A SAMPLE)

DOE and other US Government

- Department of Energy
 - NE
 - NNSA
 - OCED
 - ARPA-E
 - SC
 - Office of Technology Transitions
- Nuclear Regulatory Commission
- Department of Defense, Strategic Capabilities Office
- Department of State
- Department of Transportation
- NASA
- ...

Industry

- ARC Clean Energy
- Dominion Energy
- Electric Power Research Institute
- Exelon
- Framatome
- GE
- General Atomics
- HolosGen
- IL Rocstar
- Kairos Power
- Moltex Energy
- Oklo
- TerraPower
- Terrestrial Energy
- USNC
- Westinghouse
- X-energy
- ...

International Organizations

- International Atomic Energy Agency
- OECD/NEA
- KAERI, CEA, JAEA, SCK-CEN, KIPT, RSE NNC RK, ...

Universities

- MIT
- North Carolina State University
- Oregon State University
- UIUC
- University of Michigan
- University of Wisconsin
- ...

Other National Laboratories

- INL, ORNL, SNL, LANL, BNL, PNNL, SRNL, ...

FOUR NUCLEAR ENERGY EXECUTIVE ORDERS

Unleashing Nuclear Energy Deployment, May 23, 2025

Number	Title
E.O. 14299	Deploying Advanced Nuclear Reactor Technologies for National Security
E.O. 14300	Ordering the Reform of the Nuclear Regulatory Commission
E.O. 14301	Reforming Nuclear Reactor Testing at the Department of Energy
E.O. 14302	Reinvigorating The Nuclear Industrial Base

- **U.S. Executive Orders (EOs) for Nuclear Energy Overhaul – Energy Prosperity and National Security:** aimed at boosting domestic nuclear deployment to meet future energy demands, emphasizing nuclear energy as a national security priority
- **Acceleration of Domestic Nuclear Production:** The orders direct the acceleration of uranium production, enrichment, and fuel fabrication, and nuclear fuel recycling to support advanced reactor deployment
- **Reform of Nuclear Regulatory Commission (NRC):** To review its practices to foster a pro-development culture
- **Department of Energy Program Reforms:** Revise and exercise authorization powers, prioritizing projects with near-term commercial promise to align with national security and energy independence objectives
- **Whole-of-Government Approach:** Prioritize siting, financing, permitting, and use of nuclear energy, and U.S. nuclear exports
- **Lots of actions for government agencies** – 38 alone for DOE Office of Nuclear Energy

01 Speed Up Reactor Licensing

Creates expedited pathway to approve reactors tested by DoD and DOE. Establishes NRC deadline to license within 18 months.



Ramp Up Fuel Production 06

Builds out U.S. nuclear fuel supply chain. Increases enrichment and deconversion services. Releases 20 metric tons of HALEU.

02 Add 300 GW by 2050

Expands capacity to 400 GW by 2050, including 5 GW of uprates, LPO for reactor restarts, & 10 new large-scale reactor builds.



9 Key Takeaways from Executive Orders

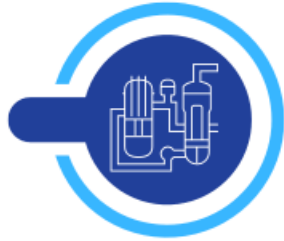


Bolster U.S. Workforce 07

Increases in apprenticeship and education opportunities. Increases access to R&D infrastructure.

03 Faster Reactor Testing

Launches new DOE pilot program to build and test three reactors by July 4, 2026.



Spent Fuel Management 08

Recommends national policy on spent fuel management and high-level waste that considers advanced fuel cycle.

04 Deploy for AI & Military

Directs DoD to build a reactor at a military installation within 3 years. Allows DOE to utilize authorities to authorize reactors for AI applications.

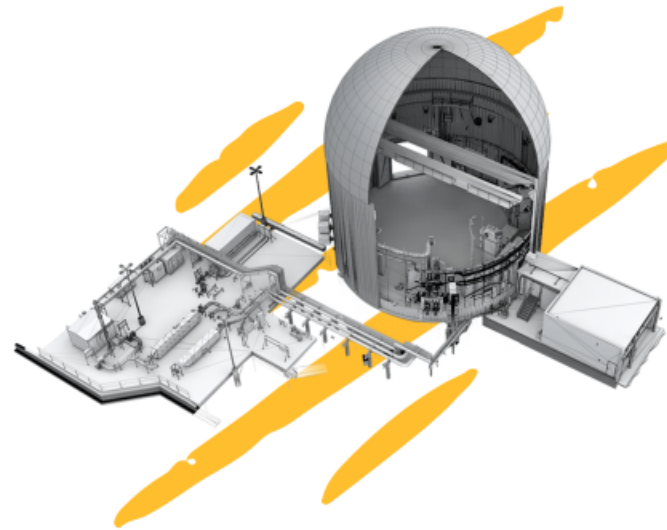


Expand U.S. Exports 09

Produces strategy to increase financing for U.S. projects and promote nuclear trade.

05 Explore Recycling

Instructs DOE to find ways to transfer commercial spent fuel to reprocessing and recycling facilities.



U.S. DEPARTMENT of ENERGY

Office of Nuclear Energy

AI × NUCLEAR ENERGY EXECUTIVE SUMMIT: UNLEASHING THE POWER FOR AI

What nuclear must deliver for AI—and what AI could deliver for nuclear

CONVENING DECISION MAKERS

80+ leaders from industry,
government, national labs



STRATEGIC IMPERATIVE

Keynote panel of National
Laboratory Directors



**6 INTERACTIVE
PANELS** to foster
a common understanding
and shared vision



**NETWORKING
OPPORTUNITIES**
Facilitate partnerships &
cross-sector relationships



AI/ML IN NUCLEAR REACTOR DESIGN, OPERATION, AND MAINTENANCE

Applications at Argonne National Laboratory

Accelerating Reactor Design

Physics-informed ML models significantly reduce computational time for simulating multidimensional flows and thermal-fluid interactions, enhancing design optimization.

Enabling Semi-Autonomous Operation

AI distinguishes between fast- and slow-changing reactor states via quantitative and qualitative models, enabling adaptive control and robust diagnostics.

Data-Driven Digital Twins

ML-enhanced digital twins forecast system behaviors under varying conditions, helping optimize reactor performance and reduce operational risks.

Predictive Maintenance Strategies

Real-time monitoring tools powered by AI identify system degradation trends, enabling maintenance before failures occur and minimizing downtime.

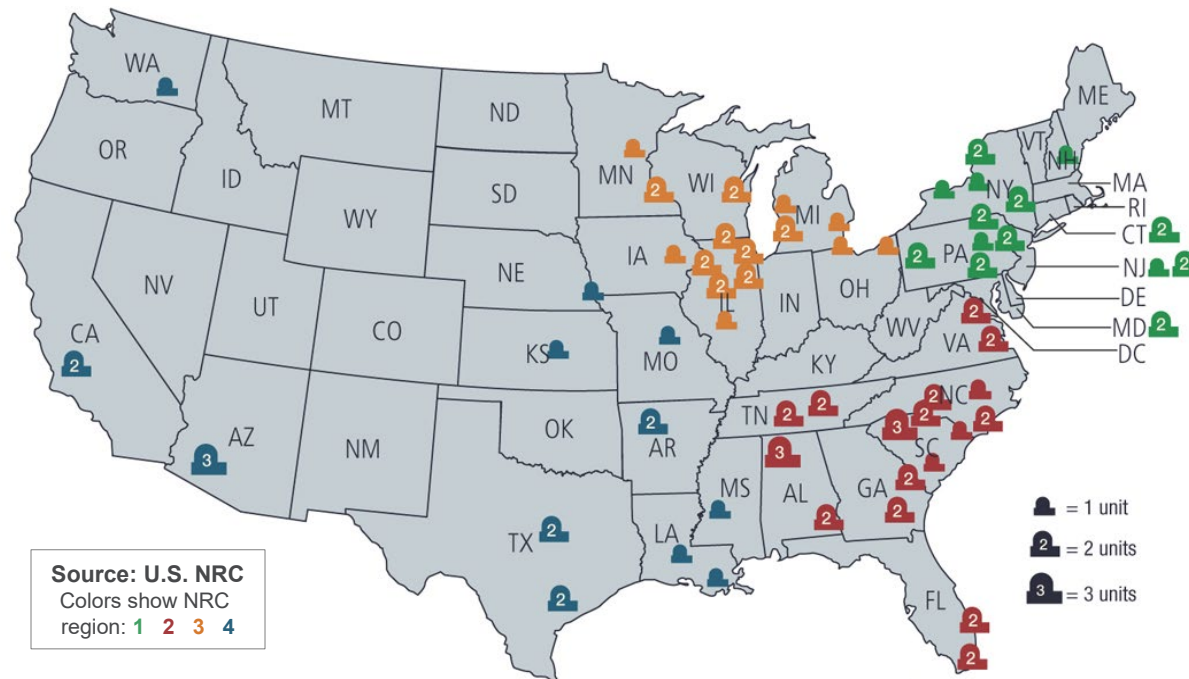


NUCLEAR POWER GENERATES ~20% OF U.S. ELECTRICITY

No option for permanent disposal of radioactive used fuel

94 OPERATING COMMERCIAL
POWER REACTORS

~2,000 METRIC TONS OF USED
FUEL PRODUCED ANNUALLY



Used fuel is government-owned,
“temporarily” stored by utilities

1976-1980: Fuel recycling paused by
Presidential Directive, due to nuclear
proliferation concerns

May 2025: Four Executive Orders to
drive advanced reactor development,
including fuel recycling