Sandia leverages over 45 years of experience informing policy decisions and leading in the development, integration, and implementation of technically safe, viable, and sustainable solutions to nuclear energy challenges, ranging from power generation to the management of spent nuclear fuel. Sandia's niche is synergizing experimental testing with high performance modeling and computation, drawing from deep expertise in the physical sciences, all engineering disciplines, geoscience, and more. A snapshot of our capabilities are listed below. Contact Sylvia Saltzstein for more information. sjsaltz@sandia.gov

SANDIA NUCLEAR ENERGY AND SPENT NUCLEAR FUEL CAPABILITIES

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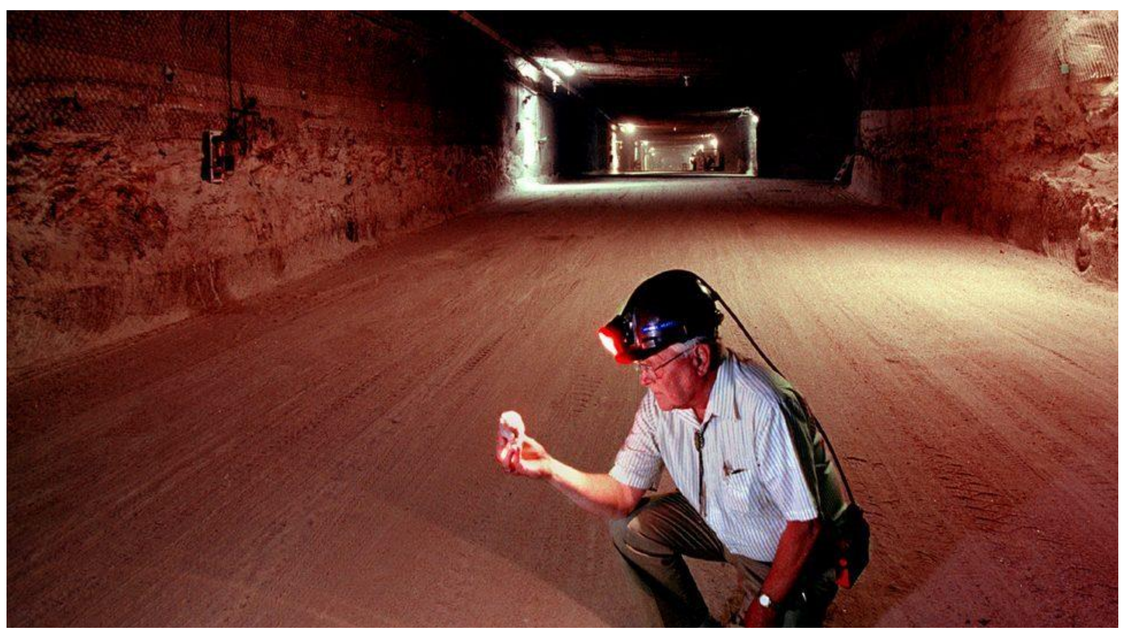
This document provides an overview of Sandia's diverse capabilities that can be applied to the Nuclear Energy Waste research space and beyond. Contact Sylvia Saltzstein (sjsaltz@sandia.gov) for more information.



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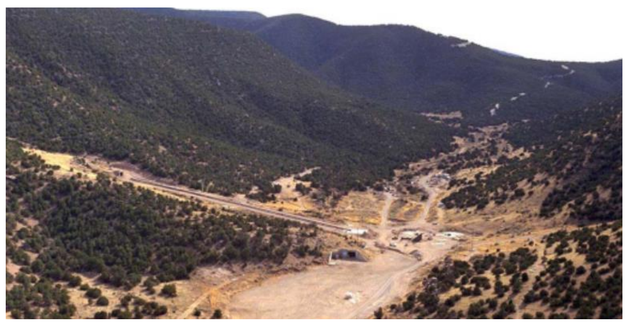
Advanced Energy Conversion and the sCO_2 Brayton Cycle

Sandia is researching a thermal-to-electric power conversion technology called a supercritical carbon dioxide (sCO_2) Brayton Cycle. This cycles uses sCO_2 as the working fluid, rather than water, increasing conversion efficiency compared to the steam Rankine cycle.

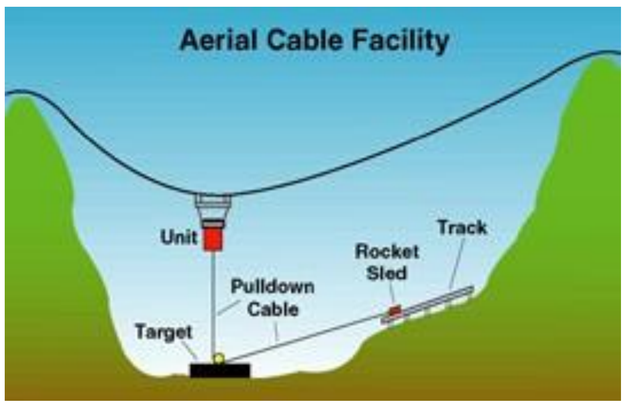
The primary reason for improved power conversion efficiency is that the use of sCO_2 as the working fluid in a Brayton cycle requires less work to convert a given thermal input to electricity. In general, increased efficiency represents increased output for the same thermal input, regardless of the thermal source (natural gas, nuclear, solar or coal). Where fuel costs are a significant portion of overall costs (coal and natural gas fired plants), the benefit is reduced fuel costs. Where capital investments are high (nuclear and concentrating solar power), the benefit is increased output for the initial investment.

Aerial Cable Facility

Sandia's Aerial Cable Facility is one of the world's largest and most experienced drop testing facilities. The facility benefits from decades of Sandia research experience in extremely short duration, large test payload, high-impact testing with state-of-the-art data collection, high definition photometrics and visualization, and analysis. Located in Albuquerque, New Mexico, the Aerial Cable Facility provides a unique capability to precisely simulate a wide variety of environments in a highly instrumented test arena.



Primary among these environments are drop and high-velocity impact testing, suspension of large items hundreds of feet above the ground, and simulated free flight along an aerial cable. The facility has four primary cable systems that span two ridges over a mountain canyon. Each cable is approximately 5,000 feet long and has endpoint anchors about 1,000 feet above the valley floor. At the center of each cable span is a flat test arena about 300 feet in diameter. The ACF includes secluded, secure, open spaces in which to conduct a variety of tests.



The hard target at the ACF was developed in the 1980s to satisfy the requirement of an "unyielding surface" for testing nuclear transportation packages (see diagram below). The target has a mass greater than 900,000 kg and, with materials such as concrete and armor steel plating, is designed not to fail after repeated impacts.

Aerosol Characterization Laboratories

Aerosol Characterization Labs provide testing capabilities and deep aerosol chemistry and physics technical knowledge.

Burn Site Testing

Sandia's Lurance Canyon Burn Site (LCBS) in Albuquerque, New Mexico, provides controlled fire environments to perform fundamental studies, simulate transportation and handling accidents for nuclear safety studies, and evaluate and certify hazardous materials shipping containers. LCBS has the following testing facilities:

- The Fire Laboratory for Accreditation of Modeling by Experiment (FLAME)
- Three open pools
- A bunker-like structure called the igloo

In the past, the LCBS was used for a variety of test and can be used for large-scale testing. The Burn Site is also used in the Sandia-hosted DOE Packaging Certification Program, which sponsors courses in "Thermal Modeling and Testing of RAM Packages" as part of the RAMPAC University.

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Drop Tower

The 185-foot Drop Tower Facility at Sandia in Albuquerque, New Mexico provides a controlled environment for testing a wide variety of small and large test items. The Drop Tower was recently used for the spent nuclear fuel 30cm drop testing and capitalizes on decades of Sandia experience in extremely short duration, large test payload, high-impact testing, data collection, visualization, and analysis. Routine tests include shipping container certification, simulated transportation accidents, and moderate velocity impact. Tests units can be temperature-conditioned from temperatures of -65°C to 100°C. Test impact targets include dirt, reinforced concrete (5 1/2 x 12 x 5 1/2 feet thick), steel plate (5 1/2 x 12 x 4 inches thick), or other customer-specified targets. Crush tests also are routinely conducted by dropping a steel mass onto a test item positioned on the target. In a similar manner, puncture tests are conducted by dropping a test item onto a spike in the target.

This facility can provide high-speed (5MHz s/s) digital data acquisition on up to 64 channels of hardwired instrumentation. A higher number of instrumentation data channels can be arranged. Transducers to measure acceleration, pressure, temperature, and strain are most often used.

Gamma Irradiation Facility and Low-Dose Rate Irradiation Facility

The Gamma Irradiation Facility (GIF) provides high-fidelity simulation of nuclear radiation environments for materials and component testing. The GIF can produce a wide range of gamma radiation environments (from 10-3 to over 6.5 x 10^2 rad/second) using cobalt-60 sources and can irradiate objects as small as electronic components and as large as an Abrams M1 tank. The GIF provides in-cell dry irradiations in three test cells and in-pool submerged irradiations.

The GIF annex, the Low-Dose-Rate Irradiation Facility (LDRIF), offers gamma (Cs-137) and neutron (AmBe) irradiation environments for long-term tests at low dose rates (from 10-6 to 10-1 rad/second for gammas and from 10-6 to 10-5 rad/second for neutrons). The GIF is a DOE Nuclear Science User Facility.

Geochemistry Laboratories

The Geochemistry Laboratories at Sandia support the investigation of basic scientific questions including material behaviors at mineral-fluid interfaces and the effects of chemical environment on fracture.

Experimental geochemistry studies allow researchers to build and test quantitative model simulations at multiple spatial and time scales. Researchers at Sandia also apply geochemistry work to a wide range of applied problems including carbon sequestration, unconventional oil and gas recovery, nuclear waste management, environmental remediation, nuclear weapons applications, and airborne contaminant detection and removal.

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Geomechanics Laboratory

The Geomechanics Laboratory at Sandia enables researchers to measure rock properties under a wide range of simulated environmental conditions, including high-pressure and complex load paths. Experiments can also determine the accuracy of design procedures in the laboratory. Making predictions of rock mass response and fluid flow through rock masses requires quantitative models of the governing deformation and fracture processes. The geomechanics laboratory allows researchers to build these complex models and perform analytic and numerical design calculations about specific rock properties.

High Performance Computing Clusters

High Performance Computing Clusters provide facilities and staffing to deliver the computational backbone behind the Sandia-developed Geologic Disposal Safety Assessment Framework, which is an open source software toolkit for probabilistic safety assessment of deep geologic disposal options. Sandia's PFLOTRAN team maintains and enhances the modeling capabilities necessary to simulate radionuclide transport in the subsurface.

International Nuclear Security Engineering Test Facilities

The Nuclear Security Technology Complex (NSTC) delivers next generation solutions to critical national security issues by providing training, demonstration, and testing capabilities for security technologies. Our staff collaborates with partners in the U.S. and abroad to advance international nuclear security.

The capabilities of the NSTC are diverse, but focus on three main areas of impact: training, demonstration, and testing and evaluation.

NSTC is a critical, one-of-a-kind resource for improving global nuclear security. Facilities include:

- Integrated Security Facility
- Sensor Test and Evaluation Center
- Outdoor Test Facility
- Access Delay Bunker

Knowledge Management

In 2019, Sandia began a knowledge management pilot program to collect, assemble, and preserve tacit knowledge from experts planning to retire on the Nuclear Energy Fuel Cycle (NEFC) components: Commercial Nuclear Power Generation (CNPG) and Back End of the Nuclear Fuel Cycle (BENFC).

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Sandia piloted a well-documented and comprehensive approach to knowledge management based on ISO 30401:2018(E) and best practices established by the Knowledge Management Institute (KMI). The approach includes Focus Group sessions, Workshop & Deep Dive interactive sessions on specific topics presented by Subject Matter Experts, and Knowledge Retention interviews with expected retirees. This approach allows for the preservation of knowledge, especially undocumented, tacit knowledge that may be difficult to document or verbalize. The group has leveraged technology by recording the sessions, both audio and video, and saved this searchable operational knowledge in a SharePoint site dedicated to knowledge management. This project has the potential to reduce or eliminate any negative impacts from the retirement of experts.

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Mobile Instrumentation Data Acquisition System (MIDAS)

Sandia created the Mobile Instrumentation Data Acquisition System (MIDAS) to provide on-site data acquisition and analysis capabilities for testing of radioactive and hazardous materials packages. MIDAS allows researchers, designers, and regulators to examine and understand how a package behaves in a variety of environments.

MIDAS is exceptionally consistent and widely trusted throughout the regulatory community; therefore, systems, subsystems, and component-level data are used to benchmark results supporting package design and certification activities. MIDAS was used for data collection during the Seismic Test in 2024 and is staffed with experienced data collection and analysis experts.

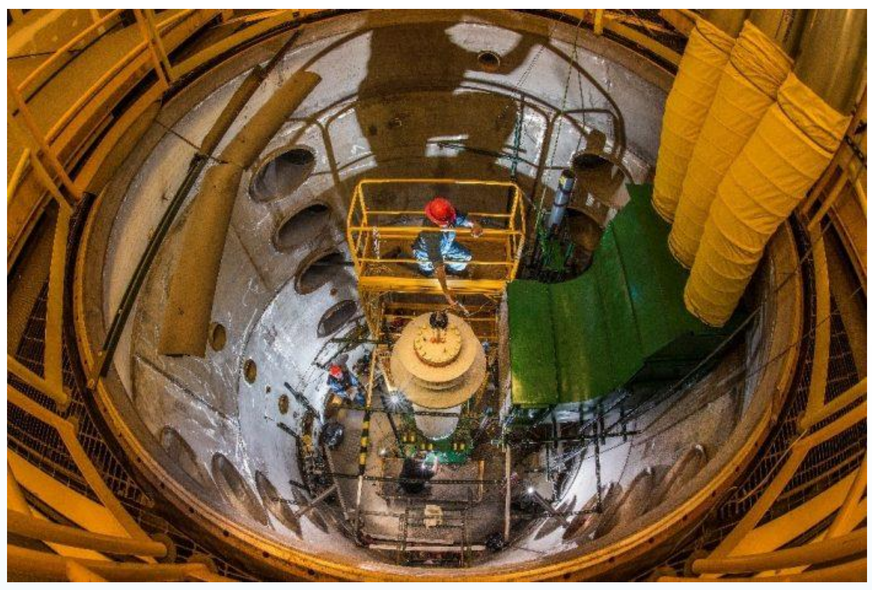
NQA1 Quality Systems

Over many decades, the Department of Energy has made significant investments in developing, building, and maintaining a large-scale testing capability at Sandia. These capabilities are used to provide qualification evidence for complex systems and materials used in packaging, storage, and transportation of radioactive materials.

The testing elements of Sandia's nuclear energy packaging, storage, and transportation research and development programs adhere to the ASME Nuclear Quality Assurance-1 (NQA-1) Quality Assurance Requirements for Nuclear Facility Applications, thereby satisfying the Title 10 CFR Part 71 Subpart H Quality Assurance requirements. The NQA-1 standard is an industry consensus standard that provides requirements and guidelines for the establishment and execution of quality assurance programs during siting, design, construction, operation, and decommissioning of nuclear facilities. It reflects industry experience and current understanding of the quality assurance requirements necessary to achieve safe, reliable, and efficient use of nuclear energy, and management of radioactive materials.

Nuclear Cybersecurity Research

The Office of Nuclear Energy sponsors cross-cutting R&D to enable the use of advanced digital technologies in the U.S. nuclear fleet. The Nuclear Cybersecurity Research (NCR) program serves both the current nuclear fleet and designers of advanced reactors and related technologies under development. There is a wide array of industrial control systems research and developing happening already, and this program has established a narrow scope to avoid duplicating those. At Sandia, we aim to adapt the best cybersecurity discoveries and practices from other sectors to the rigorous needs of nuclear power applications and to address any unique challenges not being addressed elsewhere, especially where these can enable innovative nuclear power use cases.



Nuclear Energy Work Complex

Sandia's Nuclear Energy Work Complex (NEWC) consists of two separate facilities: Surtsey and the Cylindrical Boiling facility (CYBL). Surtsey acts as the base of operations for the Nuclear Energy Work Complex and includes a machine shop, electronics shops, outdoor testing facilities, and a blast pad for high-energy tests. CYBL features a scaled reactor pressure vessel system originally designed for severe accident cooling studies. The facility also provides an outstanding controlled environment for Sandia's spent nuclear fuel combustion experiments.

The NEWC is used for thermal and drying testing, aerosol transmission testing, bentonite intrusion testing, drone testing, and dry canister mitigation technologies. The talented staff at the NEWC provide decades of experience with nuclear energy and waste heat transfer and nuclear physics large-scale test planning, set up, execution, and communication.

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Nuclear Non-Proliferation

Sandia is a recognized world leader in non-proliferation capabilities and leads the Center for Global Security and Cooperation (CGSC). The CGSC and its predecessors have supported global security and nonproliferation for more than 70 years and works to achieve global security through international technical engagement. We work with U.S. and international partners to create solutions that will proactively manage risks associated with nuclear and radiological materials, including border risk management, global civilian radiological and nuclear energy security, and countering the threat of Unmanned Aerial Systems (UAS). Through the CGSC, Sandia creates innovative technical solutions and develops enduring partnerships to assist countries in complying with international nuclear obligations. Specific technical areas include illicit trade identification and threat reduction, next generation arms control, verification, and monitoring techniques, and emerging technology assessments for safeguards and export control. Within the CGSC, Sandia leads a unique national capability: The Cooperative Monitoring Center (CMC). The CMC provides a venue in which global experts explore applications of open research and unclassified technology, including fostering partnerships, hosting visiting research scholars, collaborative experiments and tests, and building shared understanding and confidence.

Physical Security ModSim Tools

A leader in global security for more than 75 years, Sandia offers modeling and simulation (mod/sim) tools that help improve physical security through innovative physical protection system design assessment, operation, and training. Our main ModSim tools include:

- Scribe3D, used for scenario-based visualization
- PathTrace, used for pathway analysis
- CAS Simulator, used for operator training

Licensing, training, and technical support are free to approved partners. Start the process to access these tools by requesting a license.

Safety, Security, and Safeguards ModSim

The next generation of nuclear reactors and fuel cycle facilities must incorporate Safeguards, Security, and Safety by Design in order to develop safe and secure facilities that meet regulatory requirements in an efficient manner. Sandia provides safeguards analysis capabilities that tie into safety and security expertise to design and evaluate advanced safeguards and security system designs for future nuclear fuel cycle facilities.

Advanced nuclear facilities face challenges in meeting NRC regulatory requirements which were not written for small and advanced reactors and certain fuel cycle facilities. Sandia has developed a unique safeguards modeling capability for analyzing safeguard challenges and approaches for nuclear fuel cycle facilities.

Rocket Sled Track

Sandia's Rocket Sled Track Complex (RSTC), in Albuquerque, New Mexico, consists of the main Rocket Sled Track Facility and three explosive test pads, which are used to test various explosives and rocket motors.

The Rocket Sled Track provides a controlled environment for high-velocity impact, aerodynamic, acceleration, and other related testing for both small and large test items. Tests can be designed to simulate unique scenarios and to provide the maximum data from each test. The facility provides a 10,000-foot track for testing items at very high speeds, and a 2,000-foot railroad gauge track for testing very large, heavy items at moderate speeds.

The rocket sled tracks have been used for historical dry canister testing and our high-definition videographers are able to capture the test results with extreme preciseness for scientific understanding, communication, and preservation.

Cask Test - 1978

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Sandia Science for Salt Repositories

Sandia has a long history of leading the world on research into geologic salt deposits, especially for permanent disposal of radioactive waste.

The DOE Office of Nuclear Energy (DOE-NE) repository research and development program seeks to provide a sound technical basis for multiple viable disposal options, increase confidence in the robustness of generic disposal concepts, and develop science and engineering tools needed to support disposal concept implementation. Sandia, Los Alamos, and Lawrence Berkeley National labs are conducting research into salt, which includes the Brine Availability Test in Salt (BATS) field test at the Waste Isolation Pilot Plant (WIPP), a DOE Office of Environmental Management facility. BATS is leveraging the existing infrastructure associated with the WIPP to advance science informing generic disposal concepts.

Scalable Computing

The Center for Computing Research (CCR) has a legacy of leadership in high-performance computing (HPC) at extreme scales. First-of-a-kind platforms, such as the Intel Paragon, ASCI Red (the world's first teraflops computer), and Red Storm (co-developed by Cray), helped form the basis for one of the most successful supercomputer product lines ever—the Cray XT series. The CCR continues to play an important role, working closely with HPC vendors to provide solutions for next-generation systems that meet the complex mission needs of the laboratories. Our particular interests include advanced architecture design and evaluation, including Beyond Moore capabilities, scalable system software, scalable input/output, and algorithms.

Thermal Test Complex

The Thermal Test Complex (TTC) is an international resource for validation of fire physics models as well as the nuclear weapons complex hardware qualification facility for fires.

The TTC serves two functions: to evaluate the thermal loads from fire environments and the multi-physics response of hardware subject to fires. The facility has been designed to study quiescent large-scale combustion events as well as to assess the effect of wind driven fires. Fires include hydrocarbon liquid, combustible solids, and propellant fires.

The Thermal Test Facilities have been used for past testing and can be used for future Package Performance Demonstration (PPD). Sandia staff have decades in fire science and heat transfer experience to design, simulate, execute, visually capture, and communicate almost any type of fire test.

Uncertainty Quantification Tools

Uncertainty Quantification Tools provide advanced parametric analyses enable design exploration, model calibration, risk analysis, and quantification of margins and uncertainty with computational models. The Dakota project delivers both state-of-the-art research and robust, usable software for optimization and UQ. Broadly, the Dakota software's advanced parametric analyses enable design exploration, model calibration, risk analysis, and quantification of margins and uncertainty with computational models.

Waste Isolation Pilot Plant

The Waste Isolation Pilot Plant (WIPP) is the nation's only licensed and operating deep geologic repository for transuranic nuclear waste disposal. Sandia supports activities including modifications to the repository's operating permits, periodic recertifications of the repository, modifications to the repository's operating permits, and on-going monitoring of the repository performance against regulatory requirements. Building on a fifty year history with WIPP, Sandia is now engaged in shaping technical solutions to national nuclear waste management challenges that go well beyond disposal of transuranic waste.

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