University Infrastructure Upgrades: Bolstering Nuclear Energy for the Nation

by Tiffany Adams for DOE's Nuclear Energy University Program

Nuclear energy research is not consolidated in one place. Rather, it happens on a global scale, with researchers continuously perfecting solutions for the next generation of clean energy technology. Nationally, universities are key collaborators and innovators in the diverse field of nuclear energy research, and the Office of Nuclear Energy (NE) is focused on utilizing and investing in this source of knowledge and expertise.

Through the Nuclear Energy University Program (NEUP), NE integrates university-led innovation into its technical missions by way of a competitive grant process. Established in 2009, NEUP funds two types of grants: Research and Development (R&D) and Infrastructure. Infrastructure grants have been integral in strengthening the nuclear energy research capabilities of universities across the country. This support is often in the form of laboratory equipment.

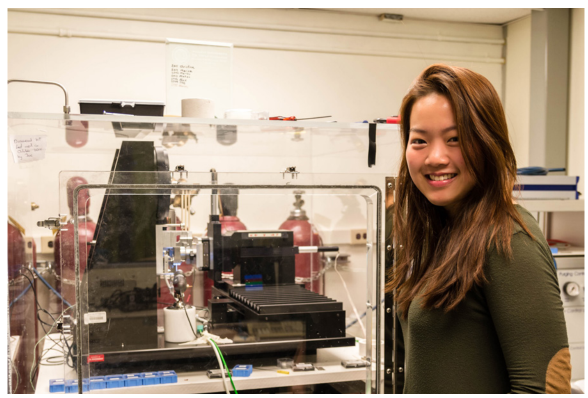
Now at the brink of the program's 10th anniversary, the Department of Energy (DOE) boasts impressive success, funding 234 Infrastructure grants at 60 institutions at a value of more than $60 million to date. Split between two focus areas, General Scientific Infrastructure (GSI) and Reactor Upgrades, DOE has funded projects such as a nuclear power plant simulator at The Ohio State University and the replacement of cooling system components at Oregon State University's TRIGA reactor. All 24 university research reactors in the United States have been supported through NE Infrastructure grants, boosting universities' capabilities for cutting-edge research and for educating the next generation of the nuclear workforce.

Often the infrastructure upgrades develop or strengthen a unique capability beneficial to researchers from more than just the university at which the capability resides. Historically managed by NEUP, the Infrastructure grant process now resides with the Nuclear Science User Facilities (NSUF). NSUF, another program housed under NE, offers free access to NSUF facilities found at universities and national laboratories around the world. Through NSUF's separate competitive peer-reviewed processes, researchers can gain access to NSUF facilities for zero cost. These include the partner facilities found at universities enhanced through NEUP grants.

The University of California, Berkeley (UCB), Texas A&M University and Purdue University house three of the nation's premier university research capabilities. An overview of capabilities at each university follows.

University of California, Berkeley

For the Nuclear Materials Laboratory (NML) at UCB, Infrastructure grants have been critical to development and success. "Without this funding agency, there would be no way to provide state-of-the-art infrastructure for research and teaching," said Peter Hosemann, professor and chair of the Department of Nuclear Engineering. To date, UCB has received five Infrastructure grants for approximately $1.26 million, much of which has been used to establish and enhance the NML. This laboratory was the first to start small-scale mechanical testing on nuclear materials. Now an NSUF partner facility, the NML can be used by researchers from across the country, free of charge. "NSUF is a cornerstone for the nation's nuclear infrastructure and is essential to research and training in the area of nuclear energy," Hosemann said.



Student uses the micro-materials nanoindenter in the University of California, Berkeley's Nuclear Materials Laboratory.

Of the NML's many capabilities, NEUP funds were used to acquire items to perform mechanical testing from nanometer to centimeter from -140°C to +800°C on irradiated and unirradiated materials in different environments. Items like a high temperature furnace (<1200°C) for the existing MTS criterion model 43 tensile test frame with a maximum load capacity of 30kN. The temperatures covered include a range important for LWR accident scenarios and important for advanced reactor concepts like high-temperature gas reactors. The Bruker PI88 insitu nanoindenter capable of measuring mechanical properties up to 800°C at the nano scale probing properties of protective coatings for ATF concepts or sampling highly irradiated and radioactive materials.

$59,666,930

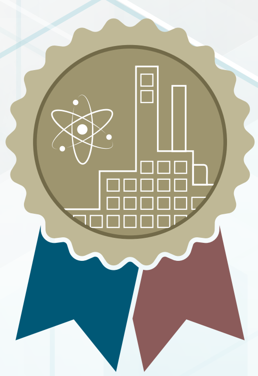
in NEUP Infrastructure grants since 2009

145

General Scientific Infrastructure awards to 60 different universities

82

Reactor Upgrade awards to 24 universities (out of 24 eligible institutions)



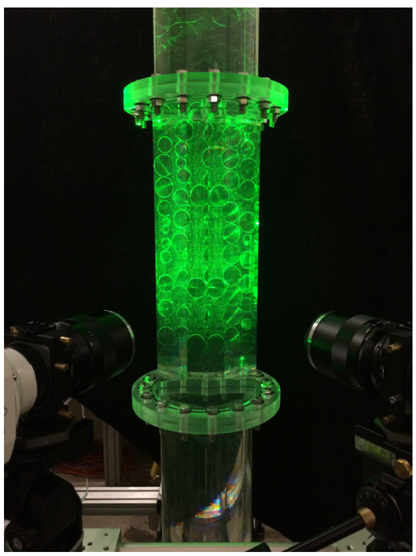
The newest addition a femto-second laser cutting system allows to process, cut, and shape unirradiated and irradiated materials to usable sample size and geometries as well as perform surface treatment on a variety of samples.

Today, several other laboratories utilize the techniques found at NML to enhance the understanding of nuclear materials. “The grants allowed us to make a lasting impact in the field and develop new nuclear technology, innovation and enhance safety in the laboratories,” said Hosemann.

Texas A&M Thermal-Hydraulic Research Laboratory

NEUP Infrastructure grants and research awards have been instrumental in developing Texas A&M’s Thermal Hydraulic Research Laboratory. The laboratory, hosted at the Texas Engineering Experiment Station, is a 14,000-square-foot laboratory with a variety of thermal hydraulic setups, including flow visualization loops and state-of-the-art instrumentation for flow measurements. The work focuses on single- and two-phase flow and multiphase flow phenomena in light water reactors, advanced reactors and high-temperature gas-cooled reactors.

Texas A&M’s advanced high-temperature reactor (AHTR) concept leverages a particle-based fuel format consisting of discrete spherical graphite pebbles arrayed in a packed bed architecture. Thermal regulation achieved via flow of gas (e.g., helium) or liquid (e.g., molten salt) coolants through the void spaces between pebbles in the bed (characteristic pebble diameters: ~ 6 cm, gas cooled; ~ 3 cm, liquid cooled).

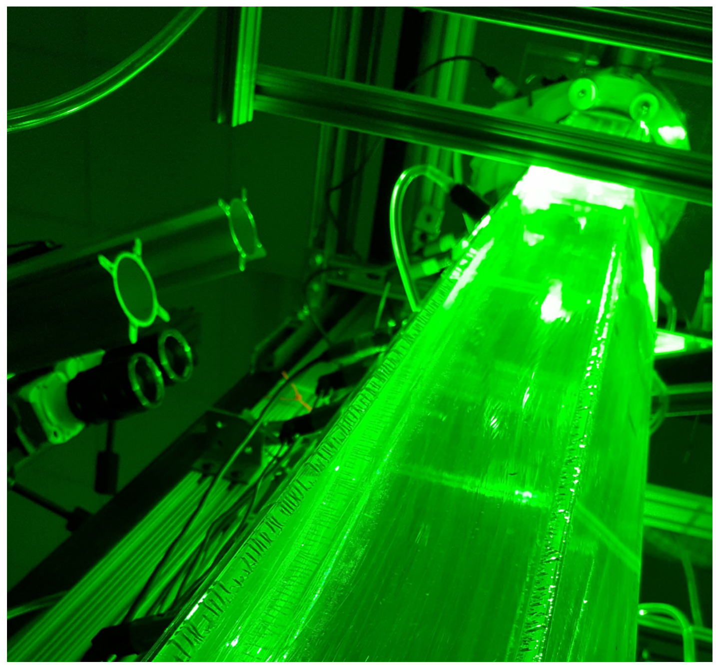


NEUP Infrastructure grants in 2009 and 2010 bolstered the laboratory with new flow measurement equipment to support a state-of-the-art three-dimensional particle image velocimetry (PIV) measurement technique using tomographic PIV. PIV was used successfully in three funded 2009 NEUP projects focused on different thermal hydraulic measurements associated with high-temperature gas-cooled reactors and very-high-temperature reactors. The Infrastructure grant, along with the experimental setups established by these three projects, provided the foundation for verification and validation of thermal hydraulic phenomena in HTGRs, which is still ongoing today.

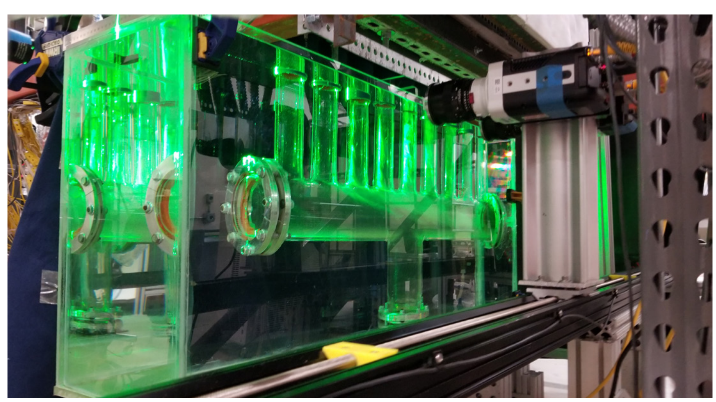
“The initial $100,000 investment in flow measurement equipment has resulted in additional investment by DOE-NE and industry,” said Dr. Yassin Hassan, the lab’s technical lead. “The lab continues to support impactful work on university, industry and national laboratory projects.”

Various projects funded through NEUP have used these facilities and capabilities, including seven NEUP projects at Texas A&M. The projects have focused on wire-wrapped fuel assemblies, water-based reactor cavity cooling systems, plenum mixing, pebble bed thermal hydraulics and air ingress accidents in high-temperature gas-cooled reactors.

Recently, the laboratory collaborated with South Texas Project (STP), utilizing the laboratory-developed measurement techniques in resolving the Generic Safety Issue (GSI-191), which has been the subject of enormous efforts within the industry for more than 20 years. The GSI-191 issue is based on a loss-of-coolant scenario in a nuclear reactor, which can generate debris and potentially affect the performance of the safety system. This project was completed successfully and saved the pilot STP power plant approximately $43 million.



The Texas A&M experiment is using the largest transparent test fuel assembly of its kind to date. In the facility, measurements of hydraulic parameters and validation of computational tools are done, just like in reactor testing and design.

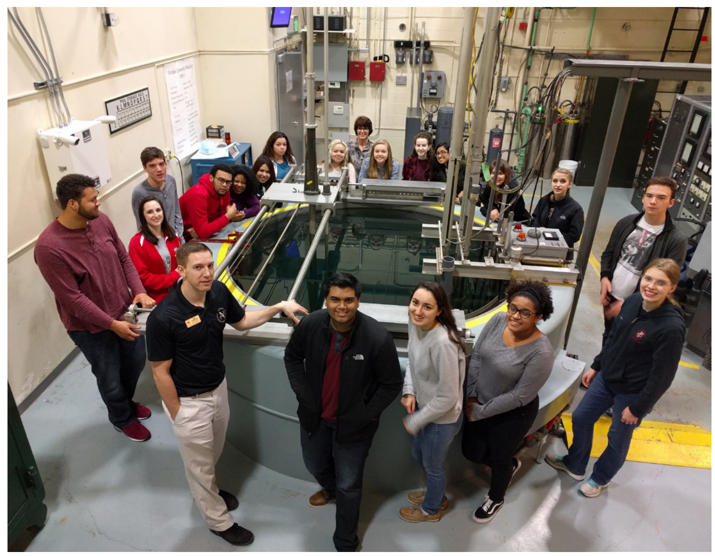


PIV, laser-doppler velocimetry (LDV) and distributed temperature sensor (DTS) measurement techniques are being applied.

PUR-1's first-of-a-kind all-digital instrumentation and control systems upgrade.

Purdue University

DOE's Infrastructure grant gave new life to Purdue University's research reactor. "We had reached a point with our equipment where we had more downtime than uptime," said Robert Bean, director of Radiation Laboratories. Completed in 1962, the instrumentation and control systems were all original, making quality replacement parts nearly impossible to find. Bean explained that, unlike a commercial reactor, test reactors don't have duplicate systems, so if the system must be paused for repairs, all research stops.



Clive Townsend, PUR-1 Reactor Supervisor (front left in black shirt), leads high school students on a tour of the facility.

Using their $1.2 million in funding beginning in 2012, Purdue upgraded their reactor control systems and reactor safety system from analog to digital. From alarm beacons to fission chamber detectors, the reactor systems were completely overhauled. "It was effectively everything," Bean said. Purdue has just been granted license approval by the Nuclear Regulatory Commission. They hope to become an NSUF partner facility, filling the void for a facility that can be used as a proof-of-concept testing ground. "It is a smaller facility, and the power level will allow more flexibility for researchers to verify their idea, that their equipment works and that their students know how to gather data," Bean said. "They can demonstrate their ideas for less."

Related NEUP Projects:

University of California Berkeley: 11-9920, 12-9836, 13-6230, 16-10916, and 18-18443; Texas A&M: 09-18963, 10-10019, and 17-18406; and Purdue: 11-9890

Release Date: October 2019

NEUP Nuclear Energy University Program
U.S. Department of Energy