UNIVERSITY PROGRAM

NC State's reactor has three main functions

North Carolina State University built what would be the first reactor in the world to operate on a university campus.

North Carolina State University's nuclear engineering program started in the 1950s, when the school was known as North Carolina State College. After World War II, scientists from Oak Ridge National Laboratory founded the program within the college's Physics Department, with plans to build an on-campus nuclear reactor. The scientists designed and built the reactor, which would be the first in the world to operate on a university campus. The project began around 1950, and the reactor was operational in 1953.

A reactor license—designated R-1—from the Atomic Energy Commission was issued retroactively after this first reactor was shut down. Over the years, the university has had several reactors on campus. One would be built and operated, and then it would be retired and a new, more functional one would start up.

Hawari

The university's existing reactor is its fourth one—a 1-MW PULSTAR design built by American Machine and Foundry—that has been in operation since its startup in 1972. The reactor is an open-pool design, moderated and cooled by light water and fueled by uranium dioxide enriched to 4 percent in uranium-235. It is unique in that no other reactor on a U.S. university campus has a similar core, according to Ayman Hawari, a nuclear engineering professor and the director of NC State's Nuclear Reactor Program. The reactor core is laid out in a 5×5 array of fuel assemblies, which resemble those in light-water power reactors because of their looks, the materials they are made from, and the fuel type.

The R-1 reactor during construction in the early 1950s on the campus of what was then North Carolina State College, now North Carolina State University (Photos: NC State)

One interesting fact about NC State's reactor is that it ran from 1972 until 2005 without being refueled. When refueling was undertaken, it was to change out only a small portion of the fuel. The time is approaching, however, when the reactor will

A view of the core of the PULSTAR reactor at 1-MW

need significant refueling, according to Hawari. The job will be performed by the Department of Energy, which has provided the university with the reactor's low-enriched fuel.

Although the reactor has never been completely refueled, a few fresh fuel assemblies that were stored on site have been loaded and the core reshuffled, a job done by the university's reactor staff under licensing limits set by the Nuclear Regulatory Commission.

The reactor initially operated on a 20-hour-per-week schedule, but it has been ramping up so that operations will soon near 40 hours per week, according to Hawari. "Because of this ramp-up, it is actually starting to make us feel we will need extra fuel," he said.

The reactor has three main missions, Hawari said. The first one is education. "We provide educational services to our local students in nuclear engineering," he said. "We also have the capability to do distance-type education through the Internet."

The reactor's operations are connected to the Internet, so students at off-site locations can participate through video-conferencing and data links to collect and analyze data and to communicate with operators who staff the reactor to execute experiments. Other schools associated with NC State's distance education have been the University of Tennessee and Georgia Tech. There also have been discussions about implementing distance education with other universities, including South Carolina State University (which has an undergraduate program in nuclear engineering) and on an international basis with countries that don't have reactors. Hawari said that NC State is working with the International Atomic Energy Agency to determine whether the use of the reactor in distance learning is feasible for overseas institutions.

The reactor's second mission is scientific research. Several facilities were built at the reactor to support this mission, Hawari said. With the help of funding from the DOE and the National Science Foundation (NSF), the university constructed an intense positron beam at the reactor. "It's a very unique facility and the only one of its type in the nation with an intensity reaching 10^9 positrons per second," he said. The facility will be used for nano-materials research. Another unique facility funded by the DOE and the NSF is an ultra-cold neutron source, which is in advanced stages of construction and testing. NC State also has state-of-the-art facilities for neutron imaging and neutron powder diffraction, Hawari said.

The reactor's third mission is performing services for various entities for such things as neutron-activation analysis, radiation testing, and neutron radiography. Current clients include the Environmental Protection Agency, the National Cancer Institute, the National Institutes of Health, contractors of the U.S. Navy, and universities from across the United States.

In addition, the PULSTAR reactor has been designated as a partner in the DOE's National Scientific User Facility structure that was established at the Idaho National Laboratory's Advanced Test Reactor, Hawari said.

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The intense positron beam cave at the PULSTAR reactor

Currently, NC State's Department of Nuclear Engineering has a total of about 220 undergraduate and graduate students (about 150 undergrads and 70 graduate students). "There has been a big boom over the past 10 years," Hawari said. "It's a good feeling to have after the drought season that nuclear engineering education experienced in the 1990s. We have to take into account that classes are bigger now and more lab space is needed to accommodate more students."

Working in the department are 14 tenured and tenure-track faculty members, with more to be added over the next few years. "We'll probably reach numbers close to 17 or 18 faculty members," he said. There is also a staff of 15 devoted to the operational and research activities of the Nuclear Reactor Program.

Hawari noted that research reactor facilities on university campuses are a strong asset for the nuclear engineering infrastructure in general in the United States. "I feel that supporting them is essential," he said. "They can be facilities where a lot of innovation can take place. Our PULSTAR reactor is an example of innovation in education and technical research. I think that university reactors are a strong contributor to our educational mission in nuclear engineering."—*Rick Michal*