(FFTF) in Washington State. "It's vitally important to continue to have the option of nuclear power. Without facilities, we cannot train people," Duderstadt says.

Politics, space, underuse, and money—but not technical failure—figure strongly in closing university reactors. Annual operating costs range from about $100 000 for small facilities up to $11 million for what is by far the most powerful campus-based neutron source, the 10-MW Missouri University Research Reactor in Columbia, which splits time between academic and commercial use. Typically, DOE covers the cost of fuel and the host university shoulders the bulk of the operating expenses. At the University of Michigan, for example, one-third of the reactor users are local academics, says reactor director David Wehe, "but two-thirds of the financial burden is in-house." Likewise, Bernard says MIT's reactor runs at a deficit of about $500 000 a year. In fact, he adds, it's often advantageous for researchers to use a national reactor, where neutrons are free and their flux is higher.

"I would say all [university reactors] are threatened," says NIST's Rowe. "My deep concern is that each decision is made in a local, rational way, but there are bigger issues that have to be wrestled with."

Hot job market

For proponents of nuclear energy, one of the bigger issues is retaining the know-how to handle a possible resurgence in the nuclear power industry (see the article "New Designs for the Nuclear Renaissance," by Gail Marcus and Alan Levin, page 54). The US demand for nuclear engineers outstrips the supply by three to one and the gap is growing, according to DOE. Not only has the number of nuclear engineering departments shrunk by half, but in the early 1990s, undergraduate enrollments started to plummet.

Those enrollments may be picking up, if anecdotal evidence is anything to go by. The University of Missouri-Rolla runs a summer camp intended to attract high-school students to nuclear engineering. In 2000, says Bill Miller, a nuclear engineer at the Missouri-Columbia campus, "seven people signed up. Last year, they had sixty." The upturn is partly because of the whole energy situation, Miller says. "The California energy crisis, concern about greenhouse gases. And it's partly because nuclear science is not just nuclear plants. We have so much going on in the life sciences, medicine, analysis of exotic materials. Society is starting to figure this out."

Another example is Texas A&M University, which in 1998 had 55 nuclear engineering majors. In 2001, it counted 134. "There's a hot job market, and starting salaries are enormous," says department head Alan Waltar. "Our graduates, with a BS, have garnered the highest salaries in the whole university. That's a major factor in our surge in undergraduate enrollment."

Just as negative public perception of anything with the word "nuclear" was a driver in the declines in the numbers of nuclear engineering departments and university reactors, renewed national interest in energy independence may buoy both. "I am hoping the boats are all starting to rise," says Waltar. "I am convinced that, as horrible as 9-11 was, there is a silver cloud. In the long run, 9-11 will help this whole profession enormously. We have to wean ourselves from foreign oil."

Fresh bucket of money

In 2000, Duderstadt testified before

Food Meets Physics at Irradiation Facility

The Electron Beam Food Research Facility opening late this spring at Texas A&M University in College Station weds commercial marketing research with studies on food irradiation.

Electrons from two accelerators will zap food from above and below as it passes on a conveyor belt. To penetrate more than about 15 centimeters, the facility also has an x-ray source, but no radioactive isotopes. Irradiation breaks molecular bonds, killing bacteria, insects, insect eggs, and larvae, and extending food shelf life.

Irradiation also breaks molecular bonds in the food itself and forms chemicals that don't naturally exist in food. The watchdog group Public Interest—which has sent letters protesting Texas A&M's new facility—and other opponents of food irradiation cite studies showing decreased vitamin content and dangerous and unstudied byproducts in the food. Not surprisingly, supporters say food irradiation is safe. "We do not care if the DNA in hamburger is broken up into sections," says Texas A&M biophysicist Les Braby. "That happens when we digest our food. However, one break in the DNA of a bacterium can make it impossible for that cell to reproduce, and that is all we need to prevent infection." Nutrition will be monitored, adds Mark McLellan, the new facility's director, "though the impact [of irradiation] is less than in canning or cooking."

DON PARK, IFSE/TEXAS A&M U.

FOR FOOD IRRADIATION STUDIES, beams of electrons sweep through food samples on a conveyor belt. From the horn on the left, electrons from a third accelerator hit a tantalum target, creating an x-ray source. The radura symbol (inset) lets shoppers know that food has been irradiated.

Texas A&M food scientists will focus on how irradiation affects flavor, texture, appearance, and longevity of food. They'll also study what happens to food packaging—irradiation is typically done on sealed food so that pathogens don't get in after treatment.

Food packaging will also be studied by physical scientists, who will do materials analyses on plastic and paper food wrappers. Other studies involving physical scientists include designing instruments for food irradiation, monitoring chemicals inside food packages, and calculating radiation doses. In a TV dinner-type meal, for example, says Braby, "if you have high-density turkey stuffing, the radiation incident there will be scattered and contribute to the dose other parts of the meal receive." Figuring out how to deliver the appropriate dose, he adds, is similar to computations in tumor radiation therapy.

On the commercial side, SureBeam Corp will conduct market research to look at irradiation effects on specific foods and their wrappers. The San Diego, California-based company has provided the irradiation sources and a building to house them, and will maintain the equipment for 10 years, after which ownership will transfer to the university—a gift worth about $10 million, says McLellan. "This is one of the largest-scale operations for research and test market evaluation tuned to food."

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