College of Engineering
UNIVERSITY OF WISCONSIN–MADISON

SPRING 2023 NEWSLETTER

ENGINEERING PHYSICS

NUCLEAR LEADERS

Undergrad Grace Stanke promotes clean energy as Miss America

Greetings from Madison!

Exciting changes are coming to the department! We have a long history of a strong nuclear engineering program, contributing to the existing fleet of nuclear power plants, emerging new reactor designs, and a rapidly expanding fusion energy ecosystem. Our department now has restructured to sharpen its focus on continuing this legacy.

As a first step, the engineering mechanics professors have moved to the Department of Mechanical Engineering. We will miss their contributions and collegial spirit, but know that these transitions will strengthen our academic programs and research portfolios, and thus the college as a whole. Our engineering mechanics educational programs will officially move to mechanical engineering later in the year, after review and approval by relevant campus entities.

With these changes, we will be able to focus on further strengthening our nuclear engineering program. We've increased emphasis on the technology connection between fission and fusion as we grow to support a vibrant network of emerging opportunities in both the public and private sectors. Also, pending approval, we'll change our name to the Department of Nuclear Engineering and Engineering Physics, a name that reflects our history in traditional nuclear engineering while acknowledging the intellectual breadth that includes our world-class plasma physics program.

This change will also allow us to continue enhancing our undergraduate curriculum and course offerings. The new first-year course we highlighted in a recent newsletter proved to be successful in building community among our students and helping them identify research opportunities within the department and internships in the private sector. Individual students have come to me with deep appreciation for the sense of connection they have to faculty, often in contrast with their peers in other parts of campus.

With growing interest in fusion, we will also be seeking ways to better support diverse career paths into the emerging sector. With only a few minor changes, our longstanding course that highlights the broad engineering challenges to achieving fusion energy can easily be accessible to most undergraduate students in the College of Engineering. There are also opportunities to educate professionals in new local companies like Shine Technologies and NorthStar Medical Radioisotopes as they ramp up their operations with engineering staff from many disciplines who may benefit from some formal exposure to nuclear science and technology.

In addition to our growing engagement with companies developing fission and fusion nuclear energy systems, our expertise has wide-ranging applications in other sectors. For example, we are supporting the design of next-generation accelerators at Fermilab and Oak Ridge National Laboratory, helping a medical isotope company explore new products, and testing novel materials for use in solar energy facilities. We are proud our experts can influence the design and development of real systems.

On, Wisconsin!

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Nuclear engineering student crowned Miss America 2023

When people meet senior Grace Stanke, they're often surprised to learn she's a nuclear engineer.

She doesn't fit the stereotypical image in a field where men far outnumber women.

"The first question a lot of people ask is, 'Are you going to build bombs?'" Stanke says.

In her role as Miss Wisconsin, Stanke aimed to help change people's views on the notion of "nuclear." Now, as Miss America 2023, she's taking her clean-energy solutions message—with, of course, a strong focus on nuclear energy—onto the national stage.

On Dec. 15, 2022, the final day of the Miss America Competition, Stanke became the first nuclear engineer, and only the third Miss Wisconsin, to earn the Miss America title. She also won the competition's preliminary night 2 and took home the top talent award for her violin performance of Vivaldi's "Storm."

While her message advocating for clean energy solutions includes technologies like wind and solar, she focuses mainly on promoting nuclear energy because it faces the biggest hurdles in social and political acceptance.

> "My main goal with this initiative is to help change the public perception of nuclear energy and increase awareness of the many benefits of nuclear technology," Stanke says.

"So when I tell people that I'm a nuclear engineer, they'll instead think that I generate clean energy or help treat cancer—the highly valuable things that nuclear engineers do. We have the science and technology, but we need more acceptance socially and politically to really advance our use of nuclear energy."

She believes nuclear energy will play a crucial role in addressing climate change. "Nuclear energy is safe and able to produce electricity no matter what the outside weather conditions are, unlike wind and solar," she says. "It's the kind of reliable power source that we need to meet our country's energy needs as we transition to a clean energy future."

A native of Wausau, Wisconsin, Stanke came to UW-Madison planning to study engineering. As she was going through the application process, the nuclear engineering major stood out. "Honestly, nuclear engineering just sounded really cool, so I selected it and figured I could change my major if it wasn't a good fit for me," she says.

As a freshman, she took the initiative to explore undergraduate research opportunities and ended up working on nuclear fusion research in the HSX stellarator facility on campus. That experience provided an engaging, hands-on introduction to fusion science and research—and confirmed for Stanke that nuclear engineering was what she wanted to pursue.

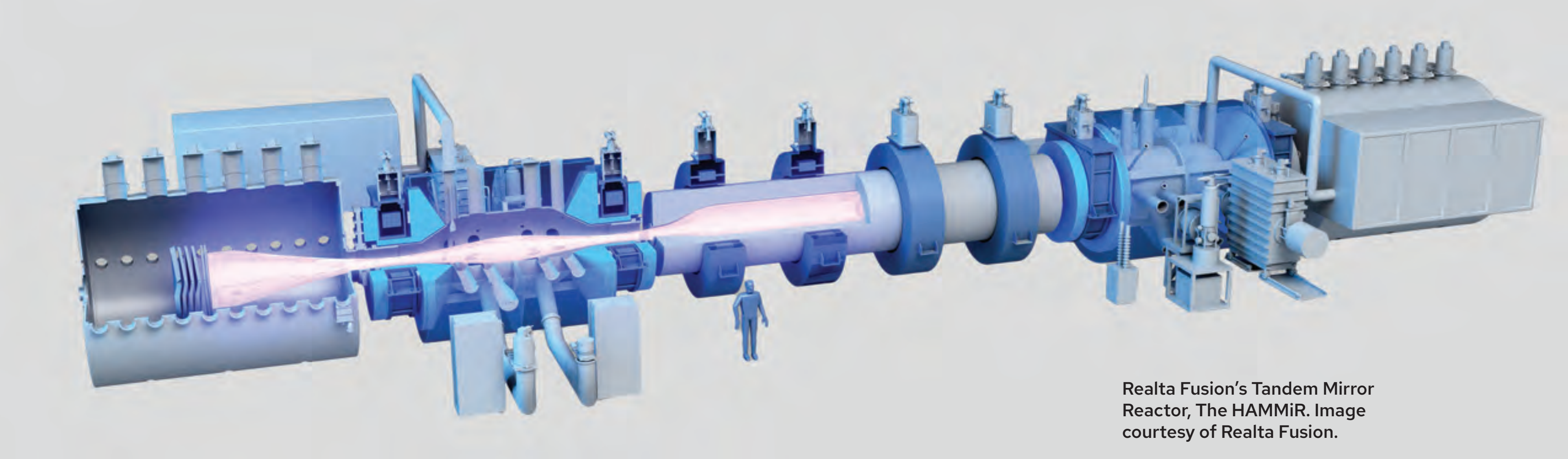
"Working at HSX was a really great opportunity," she says. "It allowed me to participate in cutting-edge research as a freshman and showed me how nuclear technology is evolving and being used right now. It opened my eyes to the capabilities of the nuclear industry and how it can benefit society."

Stanke had an internship lined up for the summer after her freshman year, but then the COVID-19 pandemic began and the internship fell through. She scrambled to apply for other opportunities in the nuclear field, and was offered a co-op with Constellation, a company that operates 11 nuclear power plants and is the nation's largest producer of carbon-free energy. She started her nuclear fuels co-op with Constellation remotely in fall 2020.

Throughout her undergraduate career, Stanke spent three semesters on co-op with Constellation, where she worked with a team of about 20 on a variety of company projects. Stanke contributed to projects ranging from low-power physics testing to creating models of the reflectors used in nuclear reactors to redirect and contain neutrons.

"I learned a lot during my co-op, and one of the things I really enjoyed was seeing my work put to use and have an impact," she says. "It also provided an opportunity to apply what I was learning in my courses to real-world challenges, which was exciting."

As Miss America, she hopes to inspire the next-generation nuclear engineers. "In addition to helping change public perception of nuclear energy and technology, I hope to inspire youth, especially young girls, to explore STEM and to see that going into these fields, including nuclear engineering, is an option for them," she says.



Realta Fusion's Tandem Mirror Reactor, The HAMMiR. Image courtesy of Realta Fusion.

Department sharpens its focus on nuclear engineering

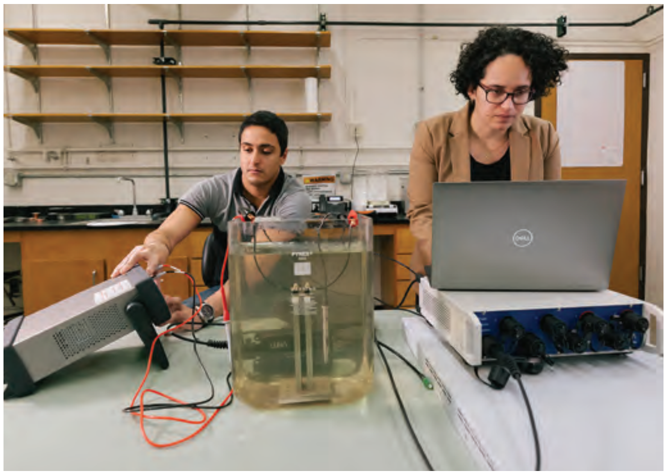
In recent years, there has been a significant rise in companies working on advanced nuclear reactor systems and fusion technology to aid in the transition to clean energy.

It's also perfect timing for the Department of Engineering Physics to sharpen its focus on nuclear engineering. Paul Wilson, Grainger Professor of Nuclear Engineering and department chair, says there's a major opportunity for the department to grow, leverage its expertise and cutting-edge facilities, and partner with these companies on innovative fission and fusion projects.

To paint a clearer picture of its refined scope, the department is seeking approval to change its name later in 2023 to the Department of Nuclear Engineering and Engineering Physics.

"With the name change, we'll be making it very clear that we are a nuclear engineering department, and this name recognition will enhance our ability to recruit faculty and students in nuclear engineering and our world-class fusion plasma physics program," Wilson says.

In 2023, the department is hiring three new faculty members with a research focus on fusion technology. Wilson says the department is particularly excited to hire faculty members whose research can bridge fission and fusion technologies, allowing the department to make a greater impact and capitalize on emerging opportunities.



Assistant Professor Juliana Pacheco Duarte, who joined the department in fall 2022, is an expert in nuclear reactor safety. Above: Duarte conducts research with graduate student Bruno Pinheiro Serrao.

For example, Assistant Professor Juliana Pacheco Duarte, who joined the department in fall 2022, is an expert in nuclear reactor safety, and she can apply her experimental and computational methods to analyze both fission and fusion reactors. "One reason I wanted to join UW-Madison is due to the many opportunities for collaboration with the large group of renowned fusion researchers here, enabling me to expand my research beyond fission," Duarte says. "In order to build fusion reactors, we also need to understand the safety aspects, cooling systems and the heat transfer process to generate electricity, and I can make a strong contribution in these areas with my research."

In the past decade, there has been substantial growth in private companies exploring novel ideas in fission energy, and the department has a strong track record of collaboration with a number of these companies, including TerraPower, Kairos, X-Energy, General Atomics, BWXT, Framatome and Westinghouse.

In one current project, Assistant Professor Ben Lindley (PI) and Associate Professor Adrien Couet are working with collaborators from Framatome, X-Energy and Idaho National Laboratory to a design a small modular high temperature reactor control rod that extends telescopically. This compact component substantially reduces the length of the depth of the silo and therefore could offer a major cost benefit.

Couet, Grainger STAR Professor Kumar Sridharan and Assistant Professor Yongfeng Zhang are leaders in studying materials for extreme nuclear environments, and they're partners in a number of research projects that are tackling key challenges for industry. Sridharan and Couet are co-principal investigators on a U.S. Department of Energy Advanced Research Projects Agency-Energy project, led by the University of Tennessee-Knoxville, that aims to develop a superior precipitation-strengthened alloy with improved creep, irradiation and corrosion resistance. The alloy will enable higher-temperature operation in molten salt nuclear reactors, fluoride-salt-cooled high-temperature reactors, and concentrated solar power systems.

"This project will benefit industry by decreasing risks associated with new alloy development and significantly accelerating the timeline for commercializing this new alloy for use in clean energy technologies," Couet says.

In addition, Zhang is lending his expertise in multiscale modeling to a University of Florida-led project that aims to understand hardening in reactor pressure vessel steels caused by manganese and nickel rich precipitates, which is a critical issue for predicting and extending reactor lifetimes.

More recently, an influx of private investment is supporting a growing number of emerging companies working on fusion technology.

"As this private money comes in to the industry, we anticipate a lot of interest in fusion technology," Wilson says. "While a lot of these companies have a good handle on the plasma physics, they don't have much expertise in the nuclear engineering aspects of making a fusion power plant, and that's where we have a great opportunity to contribute with our long history in fusion technology and power plant design studies. With recent faculty hires in the department, combined with the new hires we're currently in the process of making, we're going to be in a really exciting place to support technology developments in both fission and fusion."

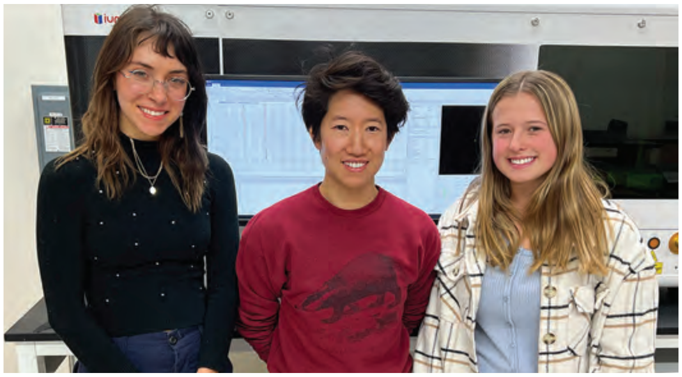
Some of these early-stage fusion companies have close ties to the department. SHINE, the Janesville, Wisconsin-based company founded by alumnus Greg Piefer (BSEE '99, MSNEEP '04, PhDNEEP/MedPhys '06), is applying fusion technology to manufacture isotopes with a range of medical applications, from diagnostic scans to treatments. Chris Hegna, the Harvey D. Spangler Professor, and Electrical and Computer Engineering Professor Emeritus David Anderson are co-founders of the startup Type One Energy Group, which aims to develop a large-scale stellarator fusion reactor that uses high-temperature superconducting magnets.

In addition, Lindley and Professor Oliver Schmitz, along with physics department faculty, are members of the founding team for Realta Fusion, an early-stage UW-Madison spinoff company that seeks to develop the lowest capital and least complex path to commercially competitive fusion energy.

The Realta Fusion team will use a reactor that's under construction—the Wisconsin HTS Axisymmetric Mirror (WHAM), led by Physics Professor Cary Forest—to demonstrate new high-temperature superconducting magnets and radio-frequency ion acceleration. This will lay the foundation for the team to design a second prototype to advance its technology for a simpler linear fusion reactor.

Lindley says the spinoff company is seeking to collaborate with multiple UW-Madison NEEP faculty in modeling and analysis of the fusion reactor, including the systems around the plasma core.

"The sharpened focus on fusion within the department leverages UW-Madison's already prestigious position as one of the top fusion engineering programs," Lindley says. "We're enthusiastic to forge a lasting partnership between Realta and the department to make a commercial fusion plant a reality, do groundbreaking science, help develop the fusion workforce and benefit the state of Wisconsin."



From left: EP PhD students Kailee Buttice and Bonita Goh and MS&E undergraduate Isabelle Baggenstoss research materials for molten salt applications as members of Associate Professor Adrien Couet's group.

Solis provides support for students studying plasma physics

Just 11% of professionals in plasma physics are women. To help spark change and broaden participation in the field, the student-led group Solis is helping to support and create community among women and gender minorities in plasma physics fields at UW-Madison.

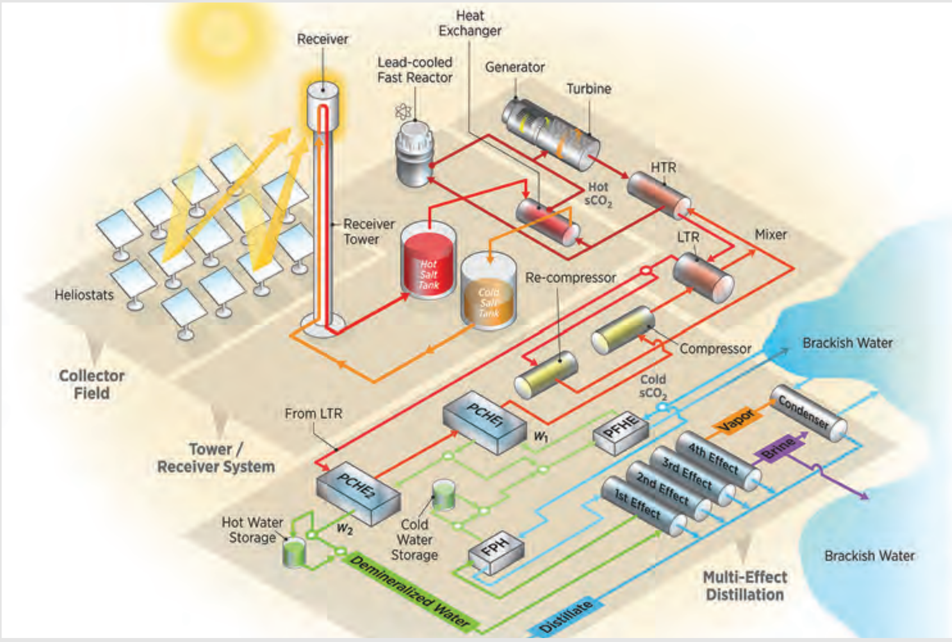
The group spans several departments across the university and includes undergraduate and grad students, bringing a community of students together who may not otherwise interact with each other outside of classes or seminars.

Solis members hope to inspire gender minorities to study plasma physics. Submitted photo.

In fall 2022, Solis led an effort to bring more gender inclusivity to the plasma physics seminars. With a grant from the UW-Madison Inclusion in Science and Engineering Leadership Institute and the support of the engineering physics, electrical and computer engineering, and physics departments, Solis invited three guest speakers to campus to give research presentations, and also to talk about their experiences and share their diversity, equity and inclusion efforts with the audience. The goal of the series was to help raise awareness and encourage audience members to take a more active role in allyship. Solis hosted a luncheon after each seminar, allowing participants to interact with the presenters in a more casual environment.

For its members, Solis provides an invaluable support network. "Even if we're talking about things that are hard to talk about, it's always a safe space," says Louise Ferris, a graduate student in the Pegasus fusion experiment group. "We're all coming to this group with the same mindset of, 'We want and need this community, so we're going to build it together.'"

Read more: go.wisc.edu/solis23



A graphic showing the research team's design for an integrated nuclear and concentrating solar power plant. Credit: Al Hicks, National Renewable Energy Laboratory (NREL).

Combining nuclear and solar tech could make a powerful pair

Ben Lindley

In energy policy debates, nuclear energy and renewable energy technologies are sometimes viewed as competitors.

In reality, they could be better, together.

Assistant Professor Ben Lindley, an expert on nuclear reactors, and Mechanical Engineering Assistant Professor Mike Wagner, a solar energy expert, are studying the feasibility and benefits of such a coupling.

In partnership with the National Renewable Energy Laboratory (NREL) and Westinghouse, they're designing an integrated energy system that combines a next-generation nuclear reactor and a concentrating solar power plant. In addition, they're developing tools and algorithms to optimize the energy production of these systems.

"With the growing use of variable renewable energy sources like wind and solar, there's increasing fluctuation in electricity prices and it's more important for energy technologies to be able to flexibly adapt their power output to match demand," Wagner says. "The challenge we're trying to solve is figuring out how to integrate a nuclear reactor and concentrating solar power in a cost-effective way that allows the entire plant to be more flexible in responding to energy markets."

In the integrated energy system, the concentrating solar power plant—specifically, its built-in thermal storage—would provide that enhanced flexibility. Concentrating solar power plants produce heat from the sun in the day, store this heat in large tanks of molten salt, and dispatch the heat as electricity when the demand is high, typically in the evening.

Lindley and Wagner created models to investigate synergies of coupling a lead-cooled fast reactor and a concentrating solar power plant in a single power cycle, with each sharing the molten salt thermal energy storage. They analyzed how a utility might go about coupling a lead- cooled fast reactor and concentrating solar power and identified configurations for doing that efficiently.

"We were able to uncover a good balance between efficiency and components synergy in this integrated energy system," Lindley says.

In other words, the two energy sources can share many components, and that can significantly reduce the capital costs. Much of the researchers' work also can apply to other advanced nuclear reactor technologies that operate at higher temperatures.

Read more: go.wisc.edu/lindley23

Student gains international perspective on nuclear

Ryan Dailey, a graduate student in Assistant Professor Ben Lindley's group, attended the 2023 Nuclear Innovator Cultivation Camp (NICC) hosted by Tokyo Tech and funded through Japan's Ministry of Education, Culture, Sports, Science and Technology. NICC aims to cultivate and foster scientists who will be successful in international collaborations and in leading innovations in nuclear technology. Over the 10 days of the camp, participants attended seminars, collaborated on group projects and visited the Fukushima Daiichi and Daini nuclear power plants.

In their free time, participants had the opportunity to explore Tokyo. Dailey, who is from a small town in Wisconsin, says touring Tokyo, a city of 40 million people, was an eye-opening experience. "I'm glad we had time to go out and explore the area. You wouldn't get to have this kind of perspective-enhancement if you were just in a classroom all day talking about nuclear," he says.

Read more: go.wisc.edu/dailey23

Through NICC, graduate student Ryan Dailey gained invaluable exposure to nuclear power on an international level. Submitted photo.

From isotopes to internships, UW–Madison partnership energizes growing Wisconsin company

A technician works with radioisotopes. Photo courtesy of NorthStar Medical Radioisotopes.

In late 2019, staff at Beloit, Wisconsin-based company NorthStar Medical Radioisotopes opened a package filled with radioactive materials. The delivery sparked an ongoing research collaboration with UW-Madison that's accelerating the company's emergence into an increasingly important healthcare market.

NorthStar produces medical radioisotopes and radiopharmaceuticals for diagnostic imaging procedures and targeted disease treatments, including cancer. The company had been looking for a convenient way to analyze the composition of materials through a process called neutron activation analysis.

NorthStar found that capability in the UW-Madison Nuclear Reactor, less than an hour's drive away.

The facility is an exemplar of the Wisconsin Idea: Used in teaching engineering students and for a wide range of research applications, the reactor also provides a variety of services to both campus and off-campus users; in fact, over the reactor's 50-plus-year history, its staff have irradiated materials for researchers studying everything from historical artifacts to bovine waste.

In their first project with NorthStar, reactor staff exposed various proprietary materials to neutrons, then returned the materials to the company for analysis.

"It was really beneficial to have a research reactor just down the road that could activate these materials for us, rather than having to ship samples across the country and rely on other labs to do the analysis," says Dan De Vries, who directs medical radioisotope product development at NorthStar and spearheaded the collaboration.

That first project grew into multiple projects underway with the UW reactor, as well as a laboratory-use contract with UW-Madison. The contract enables qualified NorthStar employees who complete radiation safety training to conduct radioisotope experiments in the UW-Madison Characterization Laboratory for Irradiated Materials.

"This agreement expanded the amount of laboratory space that NorthStar can take advantage of, and our employees now have the ability to work semi-independently in the UW-Madison lab to advance company projects," De Vries says. "This relationship with UW-Madison is enabling NorthStar to advance our progress, and it's very valuable for us to have this resource and reactor expertise close by."

De Vries says results from the company's tests at UW-Madison are helping to determine NorthStar's current and future development plans. For example, those experiments are informing engineering decisions for hot cells and related equipment for NorthStar's production facility expansion that's nearing completion in Beloit. Hot cells are specially designed shielded enclosures that allow workers to remotely handle radioactive material safely.

One of the NorthStar projects with UW-Madison has focused on copper-67, an emerging medical radioisotope. Radiopharmaceuticals using copper-67 could deliver targeted radiation that damages cancer cells' DNA and destroys them, while minimizing harm to normal cells.

Clinical human trials with copper-67 are currently underway. However, the chronic short supply of copper-67 and other emerging radioisotopes presents a big challenge in advancing potential therapies. There are only a small number of facilities that can produce copper-67, and none that can yet produce it at commercial scale.

"For a lot of these up-and-coming radioisotopes, the supply has always been the challenge," says Jim Harvey, NorthStar's senior vice president and chief science officer. "You can't effectively get clinical trials going if the supply is not there to support the trial. Having this relationship with UW-Madison and the research reactor helps us move our projects forward more quickly. NorthStar's goal is to get some of these critical radioisotopes out on the market at the quantities that are needed, with a path forward to reach ever increasing commercial scale, if the research and regulatory approvals are successful."

NorthStar also is working with staff at the UW cyclotron and the Department of Medical Physics, based in the University of Wisconsin School of Medicine and Public Health, to produce and experiment with radioisotopes.

De Vries says the company is interested in continuing to grow its relationship with UW-Madison into areas that include recruiting students for internships and graduates for full-time positions.

"In this specialized industry, it can be challenging to find qualified candidates who have experience in this area, ranging from the engineering side to radiochemistry," DeVries says. "So we also see this relationship as a way to grow the pipeline of qualified candidates who might work at NorthStar in the future."

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Undergrads gain hands-on experience operating nuclear reactor

The UW Nuclear Reactor has been running for a little over 60 years, and undergraduate involvement has always been a large component of its mission. Through an elective course focused on reactor operations, followed by an independent study, our students can become licensed reactor operators. As of 2022, 90 undergraduate student operators have been licensed by the Nuclear Regulatory Commission.

During an average week, the student operators run two six-hour operations, perform maintenance activities, and lead tours of the facility. “We come in in the morning and start up the reactor,” says Dan Mancheski, a junior in nuclear engineering, about an operation day. “Depending on any samples we need to run or any irradiations we need to do, we’ll do that at full power. We’ll keep it steady at full power for about six hours, then at the end of the day, we’ll shut the reactor down and close up for the day.”

Another service the reactor provides is course support. “We run on Tuesdays and Thursdays, because NE 427 and 428 run on those days and sometimes they need some support,” says Ali Holden, a sophomore nuclear engineering student.

Some labs require the students to perform various operations, while others may need irradiated samples or data from the reactor. In a new course created by Associate Professor Adrien Couet, first-year students are introduced to the nuclear reactor early in their undergraduate careers. Students also work on a design challenge involving the reactor.

Student operators Dan Mancheski, Ali Holden and Brienna Johnson say working with the reactor is a valuable experience that allows them to develop practical skills. Submitted photo.

For all of the operators, working with the reactor is an invaluable experience. They get the opportunity to gain hands-on, practical knowledge that other students may not. For senior nuclear engineering student Brienna Johnson, being a reactor operator has been one of her favorite experiences at UW-Madison. “I really love operating,” she says. “Every interview, every chance I’ve had with the department or elsewhere, I talk about being an operator and the experience. I think it has been a very defining aspect of my college education.”