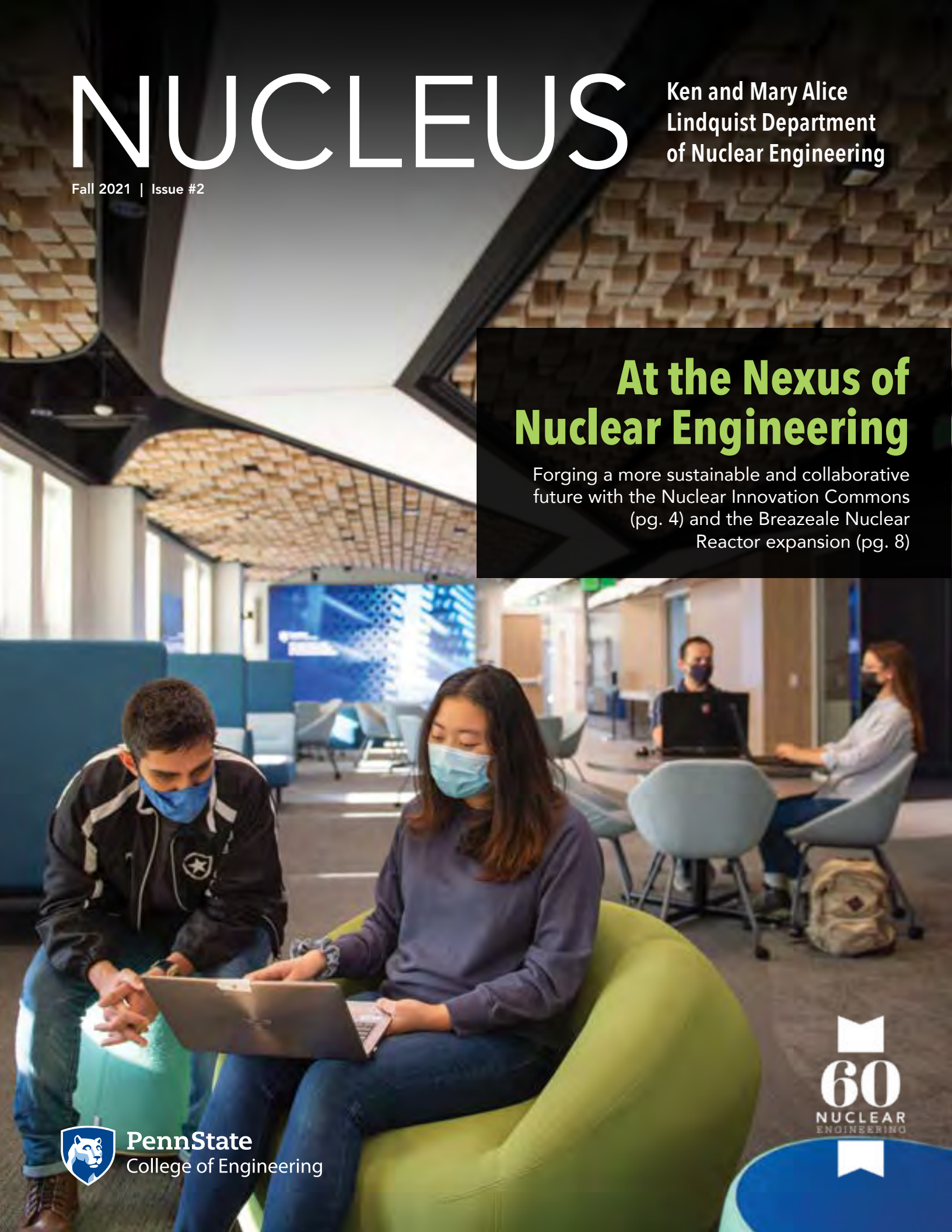
NUCLEUS

Ken and Mary Alice Lindquist Department of Nuclear Engineering

Fall 2021 | Issue #2



At the Nexus of Nuclear Engineering

Forging a more sustainable and collaborative future with the Nuclear Innovation Commons (pg. 4) and the Breazeale Nuclear Reactor expansion (pg. 8)

PennState
College of Engineering

60 NUCLEAR ENGINEERING

From the department head:

Our Promise of an Inclusive Nuclear Engineering

What an incredible year this has been, marking the beginning of our vision to establish the Ken and Mary Alice Lindquist Department of Nuclear Engineering at Penn State as one of the most diverse, equitable, and inclusive nuclear engineering departments in the country. Our staff, faculty, and students have addressed unprecedented challenges brought on by a pandemic that continues to reshape our lives every day.

This fall, we cut the ribbon to celebrate our beautiful Nuclear Innovation Commons, which will not only encourage the passion and vision of our students, staff, faculty, alumni, and friends, but will also celebrate the incredible legacy of nuclear engineering and science at Penn State. Palladino, Remick, Witzig, Foderaro, Hochreiter, and Lindquist, among others, are pioneers and trailblazers who have shaped the field nationally and beyond over the past six decades. We are honored to build upon their work and develop solutions to impact the future.

One of the most daunting challenges for our planet today is how to transition to net zero carbon emissions in only a few decades and to do so while our energy demands across the globe increase, driven by the desire for a more equitable and prosperous life. There is no other time in our history where conventional and advanced nuclear energy must have a significant role to address a scalable, credible, and just energy transition.

But nuclear is not the only answer, and we understand this. Therefore, the Nuclear Innovation Commons welcomes all: nuclear engineering students and faculty, non-nuclear engineers, and non-engineers alike. Together, we are developing innovative and transformational solutions that are not only technically sound but also socially and environmentally just.

Our Nuclear Innovation Commons is also anchored by the Nuclear Smart Lab, which facilitates virtual collaboration, and our vision for access and equitable education. We strongly support the land-grant model at Penn State, so wonderfully exemplified by campuses across the Commonwealth, to enable a nuclear engineering education for anyone who has the drive to pursue it, no matter their financial situation.

With this fully digital educational space, we created a bridge for students from all walks of life who aspire to be nuclear engineers; whether just graduating from high school or training to gain nuclear technology skills as life-long learners, the Nuclear Smart Lab at Penn State provides access to some of the world's finest nuclear engineering faculty.

This learning and practice in nuclear technology access also underpins our Nuclear to Sustainability initiative to forge partnerships with stakeholders eager to join us on our journey. Please join us in Happy Valley to celebrate this space and innovate solutions to impact people's lives and truly transform our world!

We Are! Penn State, and We Are! Nuclear!

Jean Paul Allain
Professor and Head
Ken and Mary Alice Lindquist
Department of Nuclear Engineering
allain@psu.edu

News briefs

Susquehanna Steam Electric Station

Students in the Penn State American Nuclear Society chapter visited the Susquehanna Steam Electric Station in Berwick, Pennsylvania, on April 5. The tour was arranged by **Duane Karchner**, a member of the Penn State Nuclear Engineering Society.

energy days

Penn State Energy Days

For the first time, the Ken and Mary Alice Lindquist Department of Nuclear Engineering participated in Penn State Energy Days, a two-day event hosted by the Institutes of Energy and the Environment. On May 19, the department hosted a panel, titled, "The Role of Advanced Nuclear in Sustainable Development," to discuss the benefits and challenges of various forms of nuclear energy. Convened by department head **Jean Paul Allain**, the panel included Jessica Lovering, Good Energy Collective; **Elia Merzari**, associate professor of nuclear engineering; Dennis Whyte, Massachusetts Institute of Technology Plasma Science and Fusion Center; Doug True, Nuclear Energy Institute; and John Liechty, professor of marketing and statistics. Read more

Nuclear Engineering Sixtieth Anniversary Lecture

60 NUCLEAR ENGINEERING

To celebrate the sixtieth anniversary of nuclear engineering at Penn State, the Ken and Mary Alice Lindquist Department of Nuclear Engineering hosted a virtual lecture by **Mary Lou Dunzik-Gougar**, president of the American Nuclear Society (ANS), on April 21.

Dunzik-Gougar served as the president of ANS until summer 2021. She is also associate dean of the Idaho State University (ISU) College of Science and Engineering, an ISU associate professor of nuclear engineering, and a senior reactor operator at ISU's nuclear reactor. Before joining ISU, Dunzik-Gougar worked as a joint-appointee scientist at Idaho National Laboratory and in various positions at Argonne National Laboratory. She earned her master's degree in environmental engineering and her doctoral degree in nuclear engineering, both from Penn State.

This event was sponsored by the Penn State ANS and Women in Nuclear student chapters.

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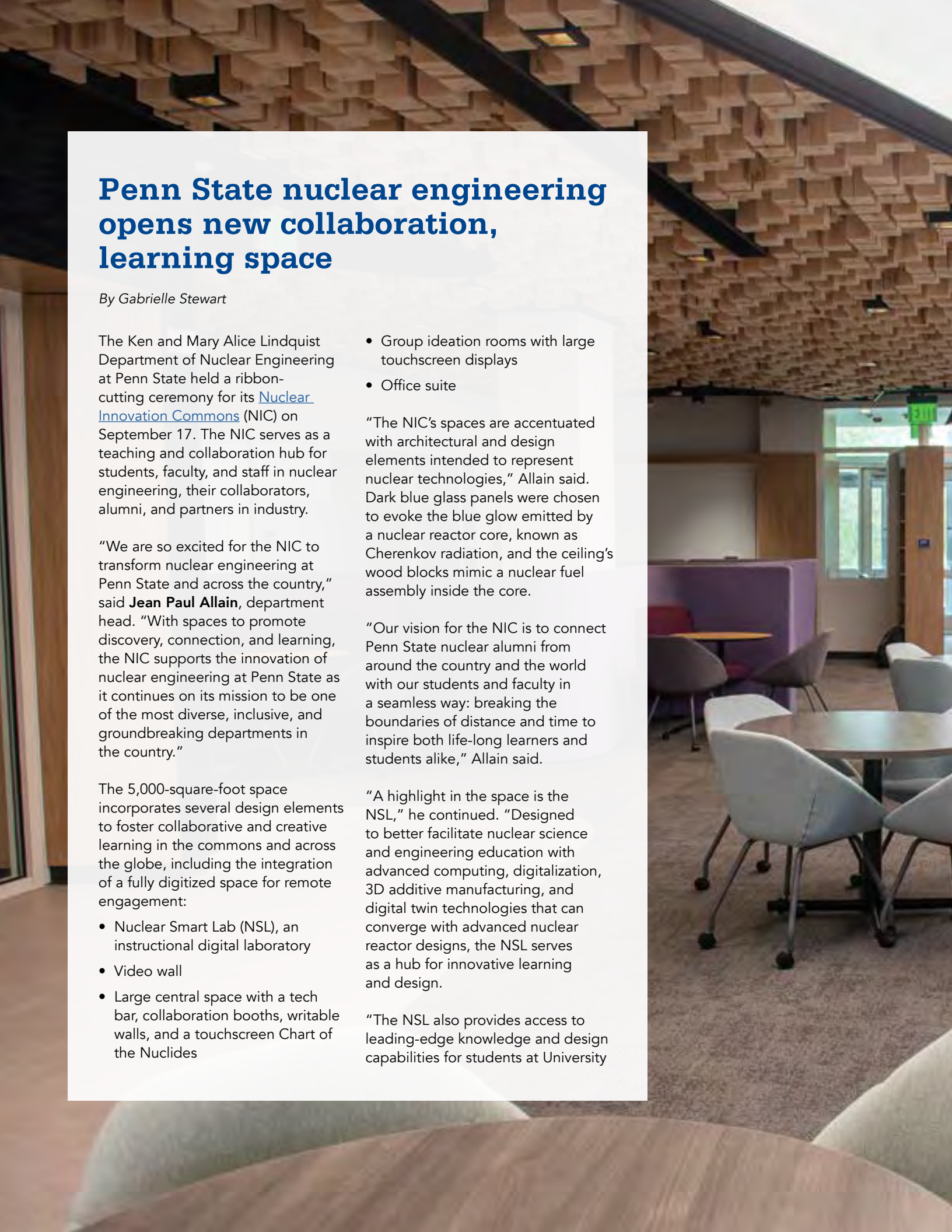


Penn State nuclear engineering opens new collaboration, learning space

By Gabrielle Stewart

The Ken and Mary Alice Lindquist Department of Nuclear Engineering at Penn State held a ribbon-cutting ceremony for its Nuclear Innovation Commons (NIC) on September 17. The NIC serves as a teaching and collaboration hub for students, faculty, and staff in nuclear engineering, their collaborators, alumni, and partners in industry.

"We are so excited for the NIC to transform nuclear engineering at Penn State and across the country," said **Jean Paul Allain**, department head. "With spaces to promote discovery, connection, and learning, the NIC supports the innovation of nuclear engineering at Penn State as it continues on its mission to be one of the most diverse, inclusive, and groundbreaking departments in the country."

The 5,000-square-foot space incorporates several design elements to foster collaborative and creative learning in the commons and across the globe, including the integration of a fully digitized space for remote engagement:

- Nuclear Smart Lab (NSL), an instructional digital laboratory
- Video wall
- Large central space with a tech bar, collaboration booths, writable walls, and a touchscreen Chart of the Nuclides
- Group ideation rooms with large touchscreen displays
- Office suite

"The NIC's spaces are accentuated with architectural and design elements intended to represent nuclear technologies," Allain said. Dark blue glass panels were chosen to evoke the blue glow emitted by a nuclear reactor core, known as Cherenkov radiation, and the ceiling's wood blocks mimic a nuclear fuel assembly inside the core.

"Our vision for the NIC is to connect Penn State nuclear alumni from around the country and the world with our students and faculty in a seamless way: breaking the boundaries of distance and time to inspire both life-long learners and students alike," Allain said.

"A highlight in the space is the NSL," he continued. "Designed to better facilitate nuclear science and engineering education with advanced computing, digitalization, 3D additive manufacturing, and digital twin technologies that can converge with advanced nuclear reactor designs, the NSL serves as a hub for innovative learning and design.

"The NSL also provides access to leading-edge knowledge and design capabilities for students at University

Park, across the commonwealth, and around the world," Allain said. "Education should be equitable, inclusive, and diverse—a major priority in our department."

According to Allain, the NIC also honors the department's current students, faculty, staff, alumni, and collaborators. The east entrance is named "Nuclear Innovation Commons Gateway: Honoring Penn State Nuclear Trailblazers, Innovators, and Friends" in recognition of nuclear engineering educators, scientists, and community members who contributed to the future of the field at Penn State.

"We are proud of the many pioneers of nuclear at Penn State," Allain said. "Their legacy inspired so many students and helped forge the department's history of cutting-edge research. We can't wait for the NIC to continue that tradition and help inspire future leaders of the field in the twenty-first century."

View the ribbon-cutting highlights.

Nuclear engineering alumni aim to connect past and future with naming gift

By Gabrielle Stewart

One plus one equals two. But one plus one can equal three when a whole is made greater than the sum of its parts by a powerful factor—a force multiplier.

This concept motivated Penn State College of Engineering alumni **Pat Loftus** and **Douglas Wood** to collaborate on a contribution for the Nuclear Innovation Commons (NIC), a 5,000-square-foot nuclear engineering collaborative space in Hallowell Building. Their gift will name the space's east lobby "Nuclear Innovation Commons Gateway: Honoring Penn State Nuclear Trailblazers, Innovators, and Friends."

"The combination of positive outcomes from our shared nuclear engineering experience was the force multiplier that made this happen," Loftus said.

Loftus earned her bachelor of science in nuclear engineering from Penn State in 1975. Upon completion of her master of science in nuclear science and engineering from Carnegie Mellon University and her master of business administration from the University of Pittsburgh, Loftus went on to advance through numerous consulting and leadership positions at Westinghouse Electric Company, Northeast Utilities, Exelon, and entrepreneurial organizations.

Wood received his bachelor of science in nuclear engineering from Penn State in 1973. After graduating with his master of science in nuclear engineering from the University of Michigan, Wood worked at Bechtel Corporation and Westinghouse before co-founding the nuclear consulting company Advent Engineering.

The donors, longtime friends who are both recipients of the Outstanding Engineering Alumni Award and past presidents of the Penn State Nuclear Engineering Society, aimed to create a name reflective of the impact their nuclear engineering mentors made.

"We have a few trailblazers in common whom we respect a great deal," Loftus said. "These larger-than-life individuals shaped the industries and communities they served intellectually and socially. They really influenced what we'd become professionally and come to value personally."

These include:

- **Nunzio Palladino**, dean emeritus of the College of Engineering and founding department head, who died in 1999
- **Warren Witzig**, adviser to Wood, and former nuclear engineering professor and department head, who died in 2007

- **Lawrence "Larry" Hochreiter**, former professor of nuclear and mechanical engineering, who died in 2008

- **Edward Klevans**, former department head and professor emeritus of nuclear engineering, adviser to Loftus

- **Jack Brenizer**, nuclear engineering doctoral alumnus, professor emeritus of nuclear engineering and former chair of the nuclear engineering programw

The name also honors nuclear engineering community members who have contributed to the field through avenues like philanthropy and student support, such as Ken and Mary Alice Lindquist, according to the donors.

"We have a vision to be one of the most innovative, diverse, and inclusive nuclear engineering departments in the country," said **Jean Paul Allain**, department head. "This gift resonates with this vision and is a terrific example to catalyze engagement with our NIC. It marks the gateway to celebrate the incredible legacy of nuclear at Penn State."

Visitors to the NIC will pass through the gateway at the east entrance. This location symbolizes the connection between the Ken and Mary Alice Lindquist Department of Nuclear Engineering and the Breazeale Nuclear Reactor on the east side of the University Park campus where the donors researched as undergraduates.

"We have shared really phenomenal lab experiences in Breazeale," she said. "We got to see the power of the atom—to live it."

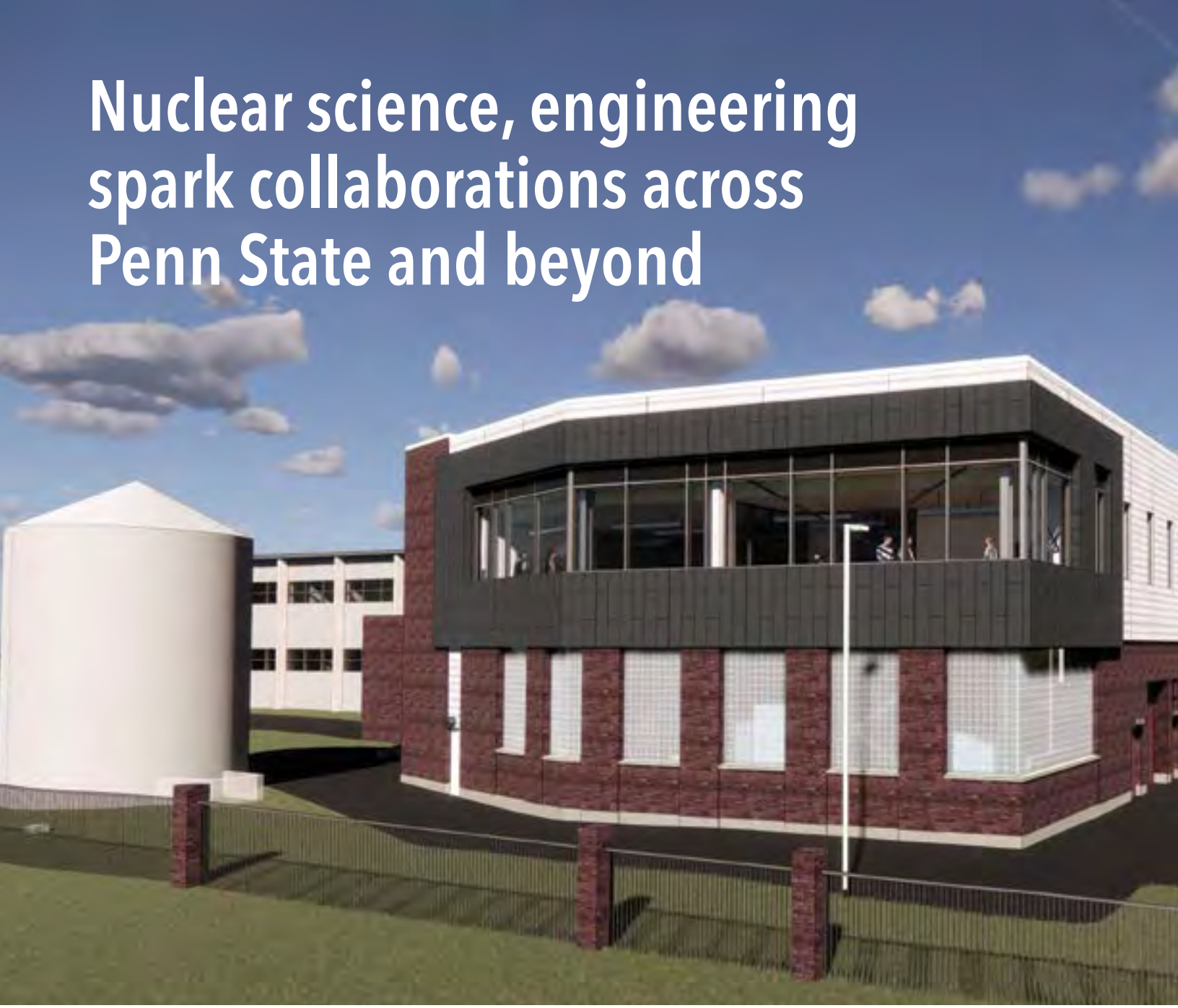
The donors, longtime supporters of Penn State nuclear engineering, plan for their gift to also celebrate upcoming nuclear engineering advocates.

"As new trailblazers, innovators, and friends emerge in future generations and make a difference for nuclear engineering, we can honor them as well," Wood said. "We want this to be welcoming and inclusive in perpetuity."

Upper left (L-R): Jeff Jeffries, Ed Klevans, Pat Loftus, Jack Brenizer, Diana Brenizer, Doug Wood
Upper right (L-R): Dick Gill, Doug Wood, Pat Loftus, Len Pasquini, Dr. Warren Witzig
Lower left (L-R): John Atchison, Pat Loftus, Doug Wood, Candace Davison, Hilary (Neal) Ruby, Tom Richard
Lower right: Dr. Warren Witzig, Doug Wood

This gift will advance "A Greater Penn State for 21st Century Excellence," a focused campaign that seeks to elevate Penn State's position as a leading public university in a world defined by rapid change and global connections. With the support of alumni and friends, "A Greater Penn State" seeks to fulfill the three key imperatives of a 21st-century public university: keeping the doors to higher education open to hardworking students regardless of financial well-being; creating transformative experiences that go beyond the classroom; and impacting the world by serving communities and fueling discovery, innovation and entrepreneurship. To learn more about "A Greater Penn State for 21st Century Excellence," visit greaterpennstate.psu.edu. To learn more about supporting nuclear science and engineering at Penn State, email Melissa Showalter at mus41@psu.edu.

Nuclear science, engineering spark collaborations across Penn State and beyond



The Radiation Science & Engineering Center and the Ken and Mary Alice Lindquist Department of Nuclear Engineering jointly map research endeavors with expansion and $9.8M equipment donation

By Ashley J. WennersHerron

Penn State's Radiation Science & Engineering Center and the Ken and Mary Alice Lindquist Department of Nuclear Engineering broke ground on a 10,000-square-foot, $9.5 million expansion of the Breazeale Nuclear Reactor on October 21. The nation's first licensed and longest continuously operating nuclear research reactor, Breazeale's expansion will accommodate an equipment donation valued at $9.8 million and facilitate more advanced neutron beam research as well as the growth of nuclear engineering at Penn State.

With the support of the College of Engineering, the Ken and Mary Alice Lindquist Department of Nuclear Engineering and RSEC are launching a joint initiative as part of the expansion to support novel studies in fundamental and applied research for Penn State faculty and students, industry, and collaborative universities and institutes.

Kenan Ünlü, RSEC director, and **Jean Paul Allain**, head of nuclear engineering, ceremoniously broke first ground and commenced construction together, serving as a symbolic demonstration of building toward a future of scientific advancement, as well as the collaborative nature of Penn State. Both spoke at the event, along with **Justin Schwartz**, Harold and Inge Marcus Dean in the College of Engineering; Lora Weiss, senior vice president for research at Penn State; Thomas Walsh, vice president and USNE regional leader at STANTEC; Dwayne Rush, project manager, Office of the Physical Plan at Penn State; **Coleman Smith**, a third-year undergraduate student majoring in nuclear engineering who works at the reactor; and **Alibek Kenges**, a graduate student in nuclear engineering.

The Breazeale Reactor

The Breazeale Reactor, which generates an enormous number of neutrons per second and enables many different types of research, was established in 1955 after President Dwight D. Eisenhower launched the "Atoms for Peace" initiative to use the relatively new-found control of the atom to benefit human life.

"The Breazeale Reactor has had several upgrades since its founding," Ünlü said. "A significant redesign and installation of five new beam ports was completed in 2018, but we needed a new and expanded neutron beam hall to make full use of the reactor's capabilities and to establish state-of-the-art neutron beam facilities."

One of five neutron beam ports will be outfitted with an "extremely" cold moderator, measuring at a temperature of 20 Kelvin (-423 degrees Fahrenheit), that allows more effective transportation of low-energy neutrons to the experimental sample location via neutron guides. This port will be dedicated to the Small-Angle Neutron Scattering (SANS) instrument. The SANS instrument was donated by Helmholtz-Zentrum Berlin, Germany, where it was previously installed at a reactor. Ünlü learned of the instrument after giving a talk in 2018 at the International Atomic Energy Agency in Vienna, Austria, when a colleague from Germany mentioned equipment that was available in Berlin. Ünlü secured the donation, which will be transferred to Penn State in late spring of 2022 when the new beam hall construction is completed.

"The Penn State RSEC's Breazeale reactor will be the only university research reactor with a SANS facility in the United States," Ünlü said.

The power of neutrons across disciplines

The instrument will enable two research options in one beam line: continuous neutrons and pulsed neutrons. Both approaches allow researchers to measure how neutrons scatter when they interact with a variety of sample materials, as well as control which parameters the researchers choose to track when investigating different aspects of the samples.

"Neutrons are an ideal probe for the investigation of complex materials, including biological materials at the atomic scale," said Allain. "SANS is an excellent technique to probe many novel and complex materials systems including soft matter, glasses, biomimetic structural proteins, microemulsions, flexible electronics, and many more systems."

Penn State Neutron Science Advisory Council

To oversee the design, management, and organization of the Penn State SANS facility, Allain and Ünlü convened leading neutron scientists to establish the first Penn State Neutron Science Advisory Council, chaired by Robert Dimeo, director of the National Institute of Standards and Technology Center for Neutron Research. Dimeo is also a Penn State alumnus, who earned his master of science in electrical engineering in 1994 and his doctorate in physics in 1999.

"The SANS facility has broad applicability across a wide swath of disciplines, and the facility at Penn State provides opportunities not just for research impact, but also for educating and training students," Dimeo said. "When I was a graduate student, I would've loved to have had access to something like this right on campus."

According to Dimeo, at least half of all beamtime requests—the reservations to use neutron science facilities for various research purposes—across the country are rejected due to lack of resources.

"This facility provides opportunities to expand research capabilities across Penn State and to help support operations for the scientific community across the United States," Dimeo said.

The research capabilities go beyond nuclear science and engineering, according to Allain and Ünlü. Eberly College of Science and the College of Earth and Mineral Sciences, as well as the Huck Institutes of Life Sciences and the Materials Research Institute all have faculty eager to see what the SANS instrument might reveal about their subject matter of choice, Allain said.

"The new SANS equipment will provide the opportunity to study the detailed atomic structure of glasses and other materials, providing key insights into the relationships between atomic structure and the macroscale properties of a wide range of materials," said John C. Mauro, professor and associate head for graduate education in the Department of Materials Science and Engineering in the College of Earth and Mineral Science. "More broadly, SANS will provide a platform for cross-disciplinary collaboration among nuclear engineering, materials science and engineering, physics, chemistry, and other departments at Penn State."

Premier neutron science destination

The planned expansion also demonstrates a close collaboration and deep commitment between RSEC and the Ken and Mary Alice Lindquist Department of Nuclear Engineering, which is experiencing an unprecedented growth of faculty and students since its establishment in the summer of 2019, according to Allain. The expansion will include office spaces for RSEC staff, nuclear engineering faculty, graduate students, and visiting scientists who will collaborate with Penn State faculty on the new SANS instrument and the Breazeale Reactor.

"The education and research mission of the nuclear engineering department and RSEC have enjoyed a strategic partnership for many decades in the College of Engineering," Allain said. "Strengthening already close ties, the college is making a significant investment in both the department of nuclear engineering and RSEC."

According to Allain, the expansion is a worthwhile investment for the College of Engineering that will reap benefits for the University and beyond. He noted that Penn State's expansion of nuclear science and engineering will also accommodate industry stakeholders for collaborative research projects, as well as serve as a key attraction in recruiting top faculty and students.

"The partnership between Drs. Ünlü and Allain to not only organize the physical upgrades but to also initiate truly transformative research and curriculum efforts is a stellar example of the interdisciplinary work that positions the Penn State as a leader in nuclear research," said Schwartz. "Penn State is becoming one of the nation's premier neutron science destinations—a vibrant hub of students and researchers engaged in multidisciplinary education and research."

66
BREAZEALE
Nuclear Reactor

Radiation Science & Engineering Center

NEWS AND UPDATES

The Radiation Science & Engineering Center (RSEC) was established in 1990 to manage Penn State's comprehensive nuclear research facilities, including the Breazeale Nuclear Reactor, the Gamma Irradiation Facility, radioactive sources, and radiation measurement resources. The RSEC is an independent unit under the vice president for research and the dean of engineering at Penn State. The RSEC provides safe nuclear analytical and testing facilities in support of research and education for faculty, staff, and students at Penn State. RSEC's resources are also available to users from other universities, governmental agencies, and industry partners, as part of Penn State's public service mission as a land grant institution. The RSEC facilities, most of which are housed in the Breazeale Nuclear Reactor Building, are some of the most unique and flexible in the United States.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Message from the director

The Radiation Science & Engineering Center (RSEC), home of the Penn State Breazeale Reactor (PSBR), promotes research, education, and applications of radiation and nuclear science and engineering to students, faculty, and staff at Penn State, as well as to scientists in universities, governments, and industries worldwide. As we celebrate sixty-six years of operation, with a rich history and countless achievements in research, teaching, and service activities, and as we embark on our next stage with a multi-million-dollar expansion, I would like to highlight some of our recent accomplishments.

- The RSEC has continued with all essential projects with outside entities, faculty, and graduate student research since the onset of the COVID-19 pandemic. Dedicated RSEC staff followed established rules and regulations related to virus mitigation and successfully provided neutron and gamma irradiation, performed reactor maintenance and checks, fuel loadings, and all other required Nuclear Regulatory Commission-related inspection activities.
- RSEC is preparing to install a Small Angle Neutron Scattering instrument, worth $9.8 million and donated by Helmholtz Zentrum Berlin in Germany after many trips to Berlin and a letter of interest from Penn State. Together with the Ken and Mary Alice Lindquist Department of Nuclear Engineering, we formed a Neutron Science Advisory Committee and identified potential users of Penn State SANS across the University and beyond.
- To fit the SANS instrument and other neutron beam facilities, we are constructing a new beam hall. With more than ten years of planning, including several ups and downs, the 10,000-square-foot expansion project was approved and funded by the College of Engineering ($9 million) and RSEC ($1 million). The U.S. Department of Energy (DOE)'s Nuclear Energy University Programs has contributed $360,000 to install a new waste storage tank in the new space, about half of which will accommodate state-of-the-art neutron beam facilities, including SANS. The other half will house offices for nuclear engineering faculty, RSEC staff, graduate students, and visiting scientists. Construction is underway and will be completed in summer of 2022, immediately after which we will install the SANS instrument.
- A mesitylene-based, third-generation cold neutron source will be installed and tested by the end of 2021.
- The designs for a new supermirror neutron guide system for in-pile and out-of-pile sections of the SANS beamline, as well as two other cold neutron beam lines were completed. The in-pile section of the guide will be delivered by the end of 2021.
- We used neutron imaging to perform some measurements of a piece of aluminum that may belong to Amelia Earhart's airplane, which prompted wide-spread interest from media outlets all over the world. We plan to conduct more measurements with our newly established Neutron Imaging Facility, which was recently verified as an ASTM Category 1 facility.
- We saw a dramatic increase in gamma irradiation-related projects after we received and installed a new 25,000 Ci cobalt-60 source for our pool gamma irradiator with $250,000 in funding from the DOE Nuclear Energy University Program.
- We received and began installing new reactor digital control system equipment, which was supported with $1.1 million from the DOE Nuclear University Program, $250,000 from RSEC, and $290,000 in equipment donated by Schneider Electric.
- Our outreach activities continued virtually. RSEC was featured in the American Nuclear Society's Virtual Field Trip, and the center hosted several virtual tours for visitors from a variety of backgrounds.
- We extend our gratitude to **Doug and Julie Moul**, who made a generous endowment gift of $100,000 to the RSEC PSBR intern training program, and to **Trudy Funer Levine** and **Samuel Levine**, who awarded an annual $5,000 scholarship to support PSBR operator trainees. This year's recipient was **Coleman Smith**, a third-year Schreyer Scholar majoring in nuclear engineering, who recently became a Nuclear Regulatory Commission-licensed reactor operator.

It is an exciting time for neutron science at Penn State, with new horizons opening for neutron science. The expansion is a dream come true for me, and I am thankful to everyone involved in making it a reality. RSEC will continue its mission of safely providing neutron and gamma-ray sources and nuclear techniques for research, education, and service into the future. With its resources, tradition of excellence, experienced nationally and internationally recognized experts, and available and planned facilities, RSEC is and will continue to be one of the major leaders of the revitalization of nuclear science and engineering in the United States.

Best Regards,

Kenan Ünlü
Director, Radiation Science & Engineering Center
Professor of Nuclear Engineering
Penn State

Clockwise from top: Kenan Ünlü, director of the Radiation Science & Engineering Center, speaks during the groundbreaking of the Breazeale Nuclear Reactor groundbreaking on October 21; Lora Weiss, vice president for research, gives remarks during the same event; Ünlü stands with Jean Paul Allain (left), head of the Ken and Mary Alice Lindquist Department of Nuclear Engineering, and Justin Schwartz, Harold and Inge Marcus Dean in the College of Engineering, after breaking ground.

Technical Updates

There have been several technical updates at the Penn State Radiation Science & Engineering Center (RSEC), including the installation of a cold neutron source, development of SANS and a neutron imaging facility, as well as a reactor console upgrade, with so much more to come. Below are more details on a few selected upgrades.

Small-Angle Neutron Scattering instrument

The work has started to prepare space for the Small-Angle Neutron Scattering (SANS) instrument, which should be installed in spring 2022. The instrument was donated by Helmholtz Zentrum Berlin in Germany, where it was previously installed on a reactor that was scheduled to shut down. The equipment will facilitate research across nuclear engineering and science and far beyond. To accommodate the Penn State and visiting collaborators, the beam hall extension will also include 5,000 square feet of office and meeting space. For more information about SANS, see page 8.

Neutron Imaging Facility

A new Neutron Imaging Facility (NIF) was designed, constructed, and implemented at RSEC with various collimators and filters. The facility was tested and designated as a Category I facility by the American Society for Testing and Materials, meaning the images produced are of high quality. The produced values of distance to the imaging plate and the neutron flux measurement, performed with a technique involving gold foil activation, were in the scope of the initial objectives for the system, indicating successful implementation. Developing the neutron tomography capability of the facility is a strategic next step for RSEC, according to **Kenan Ünlü**, RSEC director, and will be followed by subsequent applications of the facility to RSEC.

Cobalt-60 Gamma Irradiation Source

Gamma rays from radioactive cobalt-60 are used for a variety of applications in many research areas such as radiation effects of biological systems, electronics, and materials. At RSEC, the one gamma ray irradiation facility consists of gamma ray sources made of metal-encased, solid radioactive cobalt-60 pellets and housed in a large pool of demineralized water. The water allows dose rate changes easily, while shielding users from radiation.

The center has recently upgraded the pool irradiator facility with a planar source accessed by movable irradiation tubes that can handle larger/longer samples. This new source arrangement provides a higher dose rate and more flexibility for samples, while the movable tubes allow for specified dose rates requested by experimenters. The pool irradiator has a six-inch fixed tube with sources surrounding the tube for kilorad dose irradiations, as well as irradiation tubes that can be used for Enhanced Low Dose-Rate Sensitivity irradiations with the option to configure sources in a specific geometry. Most of the irradiation fixtures have an access tube to allow for in-situ monitoring and/or powering of the experimental equipment. Discrete neutron sources can be placed near the samples to provide a mixed radiation field. There is also a lead-shielded irradiator that has a National Institute of Standards and Technology traceable certified dose rate, used to calibrate the irradiation fixtures, and can irradiate samples in liquid nitrogen for samples that require cryogenic temperatures. These facilities can provide doses of rads to gigarads for researchers.

Digital Control System Installation

The Penn State Breazeale Reactor is controlled using an analog/digital hybrid console, with all credited safety systems performed by an analog Reactor Safety System (RSS), with redundant safety functions and operator controls performed by a Digital Control Console (DCC). The DCC was installed in 1991 and has only had one processor upgrade twenty years ago. Penn State received a U.S. Department of Energy Nuclear Energy University Program infrastructure grant in 2017, with funds earmarked for replacing both the RSS and DCC with modern digital equipment. However, moving from an analog RSS to a digital system requires an amendment to the reactor operating license, which will delay the process. The DCC replacement does not require the amendment, and installation is currently underway.

The new digital system, called the Digital Control System (DCS), is based on a program developed by RSEC engineers to monitor and control reactor systems using Foxboro field bus modules and field control processors, with a graphical user interface design based on the DCC to be familiar to the operators. The DCS installation and testing also includes work to improve compatibility between the motor controllers and the new control system.

Investigating Amelia Earhart's disappearance mystery with neutrons

By Ashley J. WennersHerron

It was 11-year-old Logan's turn to choose a television show to watch with his dad, **Daniel Beck**, in October of 2020. Logan turned on the National Geographic channel, which was airing the 2019 documentary "Expedition Amelia."

The film follows Robert Ballard, who discovered the Titanic wreckage, as he works to solve the disappearance of Amelia Earhart, who vanished during her attempt to fly around the world. Ballard does not find Amelia Earhart's plane, but the documentary highlighted an aluminum panel that could offer clues—if only the technology existed to peer past decades of damage from rolling around the ocean floor.

"Passion accidentally met expertise," said Beck, a pilot who also manages the engineering program for the Penn State Radiation Science and Engineering Center (RSEC), home to the Breazeale Nuclear Reactor. "The documentary ended with the idea that maybe, in the future, there will be technology to better examine the clues in Amelia Earhart's disappearance, including this panel. And I realized that technology exists. I work with it every day."

Beck emailed Richard "Ric" Gillespie, who leads The International Group for Historic Aircraft Recovery (TIGHAR) and was featured in the documentary. Gillespie and his wife, Pat Thrasher, founded the group in 1985 and have focused on Earhart's disappearance since 1988. In his email, Beck explained how neutron technology might be able to elucidate more information from the panel that Gillespie found on the Pacific island Nikumaroro in 1991.

Gillespie returned his email less than 12 hours later.

"We address famous aviation mysteries with science in an attempt to solve them," Gillespie said. "That's what brought us to Penn State: applying science to the Amelia Earhart mystery."

Gillespie found the metal panel in storm debris on Nikumaroro, a Pacific island about 300 miles away from Earhart's actual destination of Howland Island during her 1937 attempt to be the first person to fly around the world at the equator. It is theorized that Earhart landed on the reef surrounding the uninhabited island, where a human skeleton was found in 1940. While the bones were lost, a 2018 study found that a historical record of the bones' measurements matched Earhart's measurements closer than 99% of the rest of the population. Recently, as described in the National Geographic documentary, a skull fragment that may be from the original skeleton was found in a storage facility in a museum on a nearby island. It is currently being tested to see if it genetically matches with any of Earhart's relatives.

Beck knew they might be able to do equivalent work with the metal patch: examine it to determine what, if any, marks might reveal the history of this piece. Maybe they could unearth long-faded serial numbers or learn more about unexplained marks along the edges of the panel.

Beck brought the idea of examining the metal patch to **Kenan Ünlü**, director of RSEC and professor of nuclear engineering.

"Initially, I was a little skeptical," Ünlü said. "We've had inquiries about these kinds of things before, but we had an extensive call with Ric, who was clear that they're interested in whatever data we might be able to provide, even if it proves that the patch couldn't possibly belong to Amelia Earhart's plane. We agreed to see what we could see."

Beck and Ünlü proposed using neutron radiography and neutron activation analysis to examine the external and internal makeup of the patch, respectively.

"We can use these techniques to look at the surface images and make a qualitative and quantitative determination of ingredients," Ünlü said. "I didn't think we'd see much because aluminum is opaque to neutrons and activation analysis reveals mostly aluminum. Since it had been in the sea, we thought maybe we'd see coral buildup, maybe some surface paint on the sample."

Neutron radiography involves using neutron beams from the Breazeale Nuclear Reactor. A sample is set in front of the neutron beam, and a digital imaging plate is placed behind the sample. The neutron beam passes through the sample into the imaging plate, and an image is recorded and digitally scanned.

"As the beam passes through, if it were uniform density, we wouldn't see anything," Beck said. "If there's paint or writing or a serial number, things that have been eroded so we can't see with the naked eye, we can detect those."

Neutrons can create a contrast with materials that contain carbon or hydrogen by either absorbing or scattering neutrons.

"The other approach, neutron activation analysis, helps precisely identify the make-up of material," Ünlü said. "This approach can determine the ingredients of a materials at parts-per-million or parts-per-billion level sensitivity."

The patch appears to have axe marks along the edges, according to Beck, except for one edge where the metal was repeatedly flexed until it snapped from whatever it was attached to.

"It doesn't appear that this patch popped off on its own," Beck said. "If it was chopped with an axe, we should see peaks for iron or nickel left by the axe along that edge. Neutron activation analysis gives us that detail at a very fine resolution."

For example, from 2004 to 2012, Ünlü and his graduate students used the technique to measure concentrations of gold particles found in the dated rings of single tree that grew in Greece from 1411 to 1988. They matched gold spikes to volcanic events, which can cause major environmental impact thousands of miles away, to the exact year of the eruption.

"We're not going to find Earhart's signature on the patch or something that definitely confirms this belongs to her plane," Beck said. "We will provide more data about what this patch is."

From the first images, Beck and Ünlü said, it was clear they were uncovering new information. They are continuing to analyze the patch and likely will not reveal their findings until late spring of 2022, after more comprehensive experiments that include adjusting the irradiation time and power level of the reactor.

"What the Penn State team is learning about this artifact is beyond anything we've been able to do in 29 years of research," Gillespie said. "It's possible we'll learn something that actually disqualifies this artifact from being part of Earhart's plane, but I prefer the knowing! It is so exciting to work with scientists who share our passion for getting to the truth, whatever it is."

Watch the video: **Investigating Amelia Earhart's disappearance mystery with neutrons**

$100K nuclear engineering alumnus gift supports reactor licensing program

By Mariah Chuprinski

For **Don and Julie Moul**, Penn State has been the touchstone in their lives, the place that feels most like home amidst career changes and moves.

Don, a 1987 nuclear engineering alumnus, said his love for Penn State and experiences as an undergraduate student inspired him and his wife, Julie, to give to the Penn State Radiation Science and Engineering Center (RSEC).

Known as the Moul Family Fund for Reactor Operator Internships, Don and Julie's $100,000 endowment will allow undergraduate and graduate nuclear engineering students to earn their federal nuclear operator license through a yearlong training program and exam—all at no cost.

"We were seeking a way to give back to the University, and we wanted something that was tied intimately to our lives," Don said. "And I strongly believe the reactor internship gives students an opportunity to learn practically what is involved in being a reactor operator, knowledge that is crucial before they start their careers in industry."

Julie, a 1989 Schreyer Honors College and industrial organizational psychology alumna, said the gift allowed the duo to advance their involvement with the University.

"Don has volunteered on the Industrial and Professional Advisory Council for mechanical and nuclear engineering, and I volunteer every year as part of the alumni admissions program," Julie said. "But this gift allowed us to increase our involvement in a new way."

For Don, being exposed to the Penn State Breazeale Reactor as an undergraduate in labs and classes interested him enough to go on to a career in nuclear engineering operations. Currently, he serves as the executive vice president for the nuclear division and chief nuclear officer at Florida-based NextEra Energy, Inc.

"Not that many universities have a nuclear reactor program, which makes Penn State's unique," Don said. "In my opinion, getting an operator license while still in school, using a specific track that you can choose, is visionary."

Undergraduate engineering students interested in nuclear reactors can start training as early as their first year at Penn State and immediately get hands-on experience at the reactor facility, according to **Candace Davison**, licensed senior reactor operator and assistant director for education and outreach at RSEC.

"Students are theoretically and practically trained to operate the reactor and the auxiliary systems and safely work with radioactive materials," Davison said. "And after one year of training, they can take the test to get their operating license from the Nuclear Regulatory Commission, right at Penn State. That in turn makes them more knowledgeable and attractive to employers after graduation."

The Moul Family gift is a legacy that will continue to impact students for decades to come, according to **Kenan Ünlü**, director of RSEC and professor of nuclear engineering.

"The reactor internship helps solidify concepts students learn in a classroom and gives them a full understanding of the procedures and regulations required to safely operate a reactor," Ünlü said. "I know students in the generations to come will be positively affected by the Mouls' generosity."

"I strongly believe the reactor internship gives students an opportunity to learn practically what is involved in being a reactor operator, knowledge that is crucial before they start their careers in industry."

— Don Moul

Outreach Activities

RSEC helps military train for nuclear missions

The 20th Chemical, Biological, Radiological, Nuclear, and high-yield Explosives (CBRNE) Command leads the U.S. Army's response to such threats. Under the CBRNE Command are three Nuclear Disablement Teams (NDTs), the only squads in the Army trained to carry out missions related to approaching, assessing, and disabling nuclear or radiological weapons of mass destruction infrastructure and components. One of the teams, NDT 3, tested their skills with a training exercise at the Penn State Breazeale Reactor in September 2020.

Thirteen team members, following all COVID-19 mitigation regulations, embarked on the deployment readiness exercise and established a command post adjacent to the reactor. They treated the reactor and associated infrastructure as an unknown and entered wearing personal protective equipment to make observations and collect other information. They reported their work to **Kenan Ünlü**, director of the Radiation Science & Engineering Center, and **Jeffrey Geuther**, associate director, who confirmed their findings. The mission was considered a success and concluded with a tour of the facility.

RSEC featured in American Nuclear Society Virtual Field Trips

The American Nuclear Society brings nuclear science and engineering directly to students through free "Navigating Nuclear Virtual Field Trips." The series brings students to national laboratories and universities and introduces them to researchers using tiny neutron science to answer big questions. The Penn State Radiation Science & Engineering Center was featured in one such virtual field trip. **Candace Davison**, assistant director for education and outreach at RSEC, spoke about how the center uses radiation and cold temperatures to simulate space conditions. The segment begins at the 10:30 timestamp.

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PennState College of Engineering

KEN AND MARY ALICE LINDQUIST DEPARTMENT OF NUCLEAR ENGINEERING

Faculty highlights

Publications in 2021

So far in 2021, Penn State nuclear engineering faculty and students have collectively published nearly forty peer-reviewed papers, as well as several book chapters and a textbook. Many of these publications were co-authored by students and were recognized by various professional organizations.

The American Nuclear Society published the second volume of *Light Water Reactor Materials* on August 25. The textbook was co-authored by **Arthur Motta**, professor and graduate program chair in the Ken and Mary Alice Lindquist Department of Nuclear Engineering at Penn State, and Donald Olander, professor emeritus and the James Fife Chair in Engineering at the University of California, Berkeley, who died in April. The pair authored the first volume of the textbook in 2016. The first volume focuses on fundamental principles of nuclear materials, while the second volume aims to apply the principles to describe materials degradation phenomena in reactors, based on analytical models. Both volumes, geared toward university students and research scientists in academia, industry, or at national laboratories, feature homework problems and solved examples in the text. More information

Here is a selection of other published works, with student contributors and recognitions noted:

Jean Paul Allain

- "Synergistic Effect of rhBMP-2 Protein and Nanotextured Titanium Alloy Surface to Improve Osteogenic Implant Properties," *Metals*
- "Tailoring adaptive bioresorbable Mg-based scaffolds with directed plasma nanosynthesis for enhanced osseointegration and tunable resorption," *Applied Surface Science*
- "Design and Analysis of an Advanced Three-Point Bend Test Approach for Miniature Irradiated Disk Specimens," *Fusion Science and Technology*
- "Development of the material analysis and particle probe for Proto-MPEX," *Review of Scientific Instruments*
  - Student authors: Hanna Schamis, Camilo Jaramillo

Fan-Bill Cheung

- "Progress in Reflood Thermal Hydraulics Studies in the Past 40 Years," *Nuclear Engineering and Design*
- "Development of a Downward-Facing Nucleate Boiling Correlation for Thermal Hydraulic Analysis," *Experimental Thermal and Fluid Science*

Miamiao Jin

- "Dislocation Loops in Proton Irradiated Uranium-Nitrogen-Oxygen System," *Journal of Nuclear Materials*
- "Dissociated prismatic loop punching by bubble growth in FCC metals," *Scientific Reports*
- "Calculations of CISCC for UNF canisters through physics-guided machine learning framework," *Transactions of the American Nuclear Society*
- "Assessment of empirical interatomic potential to predict thermal conductivity in ThO2 and UO2," *Journal of Physics: Condensed Matter*
- "Hybrid diffusive-displacive helium outgassing in Cu/Nb multilayer composites," *Scripta Materialia*
- "Defect dynamics in y-U, Mo and their alloys," *Journal of Nuclear Materials*

Amanda Johnsen

- "Characterization of the Fast Neutron Irradiation Fixture at the Pennsylvania State Breazeale Reactor," *Transactions of the 2021 ANS Winter Meeting*
  - Student author: Maksat Kuatbek
- Characterization of Penn State's Reactor Core Face Irradiation Fixture," *Transactions of the 2021 ANS Winter Meeting*
  - Student authors: Susanna Angermeier, Maksat Kuatbek

Saya Lee

- "Experimental investigation of the annular flow caused by convective boiling in a heated annular channel," *Nuclear Engineering and Design*

Elia Merzari

- "Inertial Effects and Anisotropy for the Flow in a Domain of Close Packed Spheres with a Bounding Wall," *Nuclear Technology*
- "A Numerical Investigation of the Lengthscale in the Mixing-Length Reduced Order Model of the Turbulent Channel Flow," preprint
- "Feasibility of full-core pin resolved CFD simulations of small modular reactor with momentum sources," *Nuclear Engineering and Design*
- "Efficient exascale discretizations: High-order finite element methods," *The International Journal of High-Performance Computing Applications*
- "All-Hex Meshing Strategies for Densely Packed Spheres," preprint
- "Demonstration of CFD to support the coupled analysis of a reactor pressure vessel subjected to pressurized thermal shock," *Argonne National Laboratory*
- "NekRS, a GPU-wAccelerated Spectral Element Navier-Stokes Solver," preprint
- "A Code-Agnostic Driver Application for Coupled Neutronics and Thermal-Hydraulic Simulations," *Nuclear Science and Engineering*
- "ECP Milestone Report High-order algorithmic developments and optimizations for large-scale GPU-accelerated simulations," *WBS 2.2. 6.06, Milestone CEED-MS36*
- "40th Anniversary of the first international topical meeting on nuclear reactor thermal-hydraulics: Highlights of thermal-hydraulics research in the past four decades," *Nuclear Engineering and Design*
- "Cardinal: A Lower Length-Scale Multiphysics Simulator for Pebble-Bed Reactors," *Nuclear Technology*
- "Design of a Code-Agnostic Driver Application for High-Fidelity Coupled Neutronics and Thermal-Hydraulic Simulations," *EPJ Web of Conferences*
- "On the Impact of Aspect Ratio and Other Geometic Effects on the Stability of Rectangular Thermosiphons," *Journal of Heat Transfer*
  - Student author: Tri Nguyen
- "A New RANS Correction to Account for Varying Viscosity Effects", preprint
  - Student author: Victor Coppo Leite
- "Large Eddy Simulation of a 5× 5 rod bundle: Impacts of a central control rod thimble tube," *Nuclear Engineering and Design*
  - Student author: Adam Kraus
- "Direct numerical simulation of fluid flow in a 5x5 square rod bundle," *International Journal of Heat and Fluid Flow*
  - Student author: Adam Kraus
- "Comparison of Pebble Bed Velocity Profiles Between High-Fidelity and Intermediate-Fidelity Codes," *ASME 28th International Conference on Nuclear Engineering*
  - Student author: David Reger
  - Earned North America Best Paper, Third Place
- "Study on Laminar Turbulent Transition in Square Arrayed Rod Bundles," *ASME 28th International Conference on Nuclear Engineering*
  - Student author: Carolina Da Silva
  - Earned North America Best Video, Second Place

Arthur Motta

- Two of graduate students advised by Motta published their theses.
  - Pierre-Clément A. Simon (earned Ph.D. in 2021): "Phase Field Modeling and Quantification of Hydride Morphology"
  - Muhammet Ayanoglu (earned Ph.D. in 2021): "Microstructural Evolution of 21cr32ni Austenitic Model Alloy Under Heavy-Ion Irradiation as a Surrogate for Reactor Irradiation"
- "Zirconium Hydride Precipitation and Dissolution Kinetics in Zirconium Alloys," *Zirconium in the Nuclear Industry: 19th International Symposium*
  - Student author: Pierre-Clément A. Simon
  - Earned the ASTM John Schemel Award for the Best Paper
- "Corrosion and Ion Irradiation Behavior of Ceramic-Coated Nuclear Fuel Cladding," *Zirconium in the Nuclear Industry: 19th International Symposium*
- "Characterization of Long-Term, In-Reactor Zircaloy-4 Corrosion Coupons and the Impact of Flux, Fluence and Temperature on Oxide Growth, Stress Development, Phase Transformation, and Grain Size," *Zirconium in the Nuclear Industry: 19th International Symposium*
- "Quantifying the effect of hydride microstructure on zirconium alloys embrittlement using image analysis," *Journal of Nuclear Materials*
  - Student authors: Pierre-Clément A. Simon, Calion Frank (earned B.S. in 2021)
- "In-situ ion irradiation induced grain growth in nanocrystalline ceria," *Journal of Nuclear Materials*
- "Implementation and Validation of the Hydride Nucleation-Growth-Dissolution (HNGD) model in BISON," *Journal of Nuclear Materials*
  - Student author: Florian Passelaigue
- "Void shrinkage in 21Cr32Ni austenitic model alloy during in-situ ion irradiation," *Journal of Nuclear Materials*
  - Student author: Muhammet Ayanoglu
- "Characterization of in-situ ion irradiated Fe-21Cr-32Ni austenitic model alloy and alloy 800H at low doses," *Journal of Nuclear Materials*
  - Student author: Muhammet Ayanoglu
- "Sensitivity analysis of BISON model for characterization of impact of experimental parameters on hydrogen migration and redistribution in zirconium-based alloys," *Journal of Nuclear Materials*
  - Student author: Florian Passelaigue

Martin Nieto

- "Evaluation of Thorium-based nuclear fuel breeding performance of a fast neutron irradiator based on a low-aspect ratio tokamak," *Fusion Engineering and Design*

Asok Ray

- "Homeostasis and Homeorhesis: Sustaining Order and Normalcy in Human-Engineered Complex Systems," *International Journal on Engineering Technologies and Informatics*
- "On State-space Modeling and Signal Localization in Dynamical Systems," *ASME Letters in Dynamic Systems and Control*
- "Identification of Long-term Behavior of Natural Circulation Loops: A Thresholdless Approach from an Initial Respons," *Sci: An MDPI Journal*
  - Student authors: Chandrachur Bhattacharya, Rotie Saha, Aradhita Mukhopadhyay
- "Parametric Shape Optimization of Pin-Fin Arrays Using a Surrogate Model-Based Bayesian Method," *AIAA Journal of Thermophysics and Heat Transfer*
  - Student authors: Swaroop Ghosh, Sudeepta Mondal, E. Farnandez, J.S. Kapat
- "Early Detection of Fatigue Crack Damage in Ductile Materials: A Projection-based Probabilistic Finite State Automata Approach," *ASME Letters in Dynamic Systems and Control*
  - Student authors: Chandrachur Bhattacharya, Susheel Dharmadhikari, Amrita Basak
- "Transfer Learning of Deep Neural Networks for Predicting Thermoacoustic Instabilities in Combustion Systems," *Energy and AI*
  - Student authors: Sudeepta Mondal, A. Chattopadhyay, Aradhita Mukhopadhyay
- "Transfer Learning for Detection of Combustion Instability via Symbolic Time Series Analysis," *ASME Journal of Dynamic Systems, Measurement, and Control*
  - Student author: Chandrachur Bhattacharya
- "A Data-Driven Framework for Early-Stage Fatigue Damage Detection in Aluminum Alloys Using Ultrasonic Sensors," *Machines: An MDPI Journal*
  - Student authors: Susheel Dharmadhikari, Chandrachur Bhattacharya
- "Optimal Window-Symbolic Time Series Analysis for Pattern Classification and Anomaly Detection," *IEEE Transactions on Industrial Informatics*, in press
  - Student authors: I. Ghalyan, Najah F. Ghalyan
- "Thresholdless Classification of Chaotic Dynamics and Combustion Instability via Probabilistic Finite State Automata," *Mechanical Systems and Signal Processing*, in press
  - Student author: Chandrachur Bhattacharya

Kenan Ünlü

- "New Neutron Imaging Facility Development at the Penn State Breazeale Nuclear Reactor", *2021 International Conference on Advancements in Nuclear Instrumentation Measurement Methods and their Applications*
  - Student author: Alibek Kenges
- "Delivering Graduate Nuclear Security Education: Teaching Nuclear Security Policies to Nuclear Engineers," *Proceedings of INMM & ESRADA Joint Annual Meeting*

William Walters

- Book chapter: "Operational Analysis Methods," *Encyclopedia of Nuclear Energy*
- "Establishing the Feasibility of the Centrifugal Nuclear Thermal Rocket," *American Institute of Aeronautics and Astronautics Propulsion and Energy Forum*
- "Strategies for Fast Fission Matrix Estimation with Fuel Temperature and Control Rod Feedback," *Nuclear Science and Engineering*
  - Student author: Adam Rau
- "Improvements on Power Calibration and Core Monitoring at the Penn State Breazeale Reactor with MCNP," *ANS M&C 2021 – The International Conference on Mathematics and Computational Methods Applied to Nuclear Science and Engineering*
  - Student author: Gokhan Corak
- "Gamma ray signatures for identifying plutonium content changes in Molten Salt Reactors," *Proceedings of the INMM & ESARDA Joint Annual Meeting*
  - Student authors: Branko Kovacecic, Andre Vidal Soares
  - Earned the INMM Materials Control & Accountability Division Best Overall Poster Presentation

Xing Wang

- Book chapter: "New direction of nuclear code development: Artificial Intelligence," *Nuclear Power Plant Design and Analysis Codes*

Doug Wolfe

- "Improved Light Collection from Inorganic Scintillators using Photonic Crystals," *Proceedings of the INMM & ESARDA Joint Annual Meeting*
  - Student authors: Stuti Surani, Faruk Logoglu
- "Heat Transfer Enhancement of a Zirconium Heater Rod Using a Chromium Coating During Quenching," *5th-6th Thermal and Fluids Engineering Conference*
  - Student authors: Almudhi, Ebrahim, Almadih
- "In-situ ion irradiation induced grain growth in nanocrystalline ceria," *Journal of Nuclear Materials*
- "Material properties of IR-to-IR down-converting Er and Nd-Doped ZrO2 nanopowders," *Optical Materials*
  - Student authors: Lauer, Watson, Rai, Qian
- "Predicted Heat Flux Performance of Actively Cooled Tungsten-Armored Graphitic Foam Monoblocks," *Fusion Science and Technology*
  - Student authors: Klett, Williams
- "High Heat Flux Testing of Castellated Graphite Plasma-Facing Components," *Fusion Science and Technology*
  - Student authors: Gray, Ellis, Jawarski, Khdak, Looby, Reinke, Smalley

Matt Zerphy

- "Avert 4 Universities (a4u) Program Support to The Pennsylvania State University," *Proceedings of the INMM & ESARDA Joint Annual Meeting*

Faculty awards and grants:

Kenan Ünlü received the 2020 Radiation Science and Technology Award from the Isotopes and Radiation Division of the American Nuclear Society. The award is presented annually only if there are worthy candidate nominations. Ünlü was selected for "creative and impactful contributions to research reactor instrumentation and applications," according to the selection committee. With more than thirty years of research reactor administration experience, Ünlü has led the expansion of research, education, and new facilities for research reactors at the University of Texas at Austin, Cornell University, and Penn State. Read more

Elia Merzari received the inaugural Bal-Raj Sehgal Memorial Award from the Thermal Hydraulics Division of the American Nuclear Society. Award nominations are made by members of the division or others in the technical community to recognize an early-career to a mid-career individual for their exceptional and/or sustained contributions to the thermal-hydraulics field, with a particular focus on the application of thermal-hydraulics to nuclear reactor safety. The award was named in honor of Bal-Raj Sehgal, a professor at the Royal Institute of Technology in Sweden and the leading global expert in nuclear reactor safety.

Merzari currently serves as the division's chair, after his election to vice chair (chair-elect) in 2020. He has previously served as the division's secretary, treasurer, program chair, assistant program chair, webmaster, and executive committee member.

Jean Paul Allain was awarded a $758,198 grant by the U.S. Department of Energy Office of Science on August 30 as part of the office's subprogram, "Burning Plasma Science: Long Pulse and High Power." Titled, "Modeling Chemically Reactive PMI Properties of Complex W Alloys as Plasma-Facing Materials," the grant will fund a three-year project in collaboration with the Penn State Institute for Computational and Data Sciences, where Allain holds a co-appointment.

Arthur Motta will lead a U.S. Department of Energy Nuclear Energy University Program grant with collaborators **Elia Merzari**, **William Walters**, and **Mia Jin**, all faculty in the Ken and Mary Alice Lindquist Department of Nuclear Engineering, and David Andrs with the Idaho National Laboratory. The grant, "Estimation of low temperature cladding failures during an RIA transient," will fund a three-year project under the DOE "Fuel to Coolant Thermomechanical Transport Behaviors Under Transient Conditions" program.

New faculty

Miaomiao "Mia" Jin joined Penn State in January from Idaho National Laboratory, where she did her postdoctoral research after obtaining her doctoral degree at the Massachusetts Institute of Technology in 2019. Her research focuses on computational nuclear materials, using multi-scale computational methods and data-driven techniques to examine materials performance under extreme environments. Read more

Student highlights

Awards and recognitions

In spring 2021, the department awarded several students and alumni recognitions for internal and external Penn State accomplishments:

- John J. Brennan Excellence in Nuclear Engineering Award: **Nathan Kibbe**, fourth-year undergraduate
- Edward H. and Deborah R. Klevans Scholarship in Nuclear Engineering: **John Acierno**, 2021 graduate; **Kevin Jones**, fourth-year undergraduate, **Nathan Labowski**, 2021 graduate
- Monty Schultz Memorial Scholarship in Nuclear Engineering: **Lucas Burkett**, 2021 graduate; **Ryan Cassidy**, fourth-year undergraduate; **Joshua May**, 2021 graduate
- Bernadette and Warren Witzig Nuclear Engineering Scholarship: **Susanna Angermeier**, graduate student; **Victoria Hagopian**, graduate student; **Sara Kolecki**, fourth-year undergraduate
- Penn State Undergraduate Research Poster Competition, Second Place: **Christopher DeSalle**, graduate student (fourth-year undergraduate at time of award)
- Robert W. Lindsay Award in Metallurgy: **Christoper DeSalle**, graduate student

Nuclear engineering students have also received recognition from outside the University:

- **Jonathan Balog**, doctoral student: Rickover Fellowship, South Carolina Universities Research and Education Foundation. Read more
- **Matthew Durbin**, doctoral candidate: Graduate Scholarship, Nuclear & Plasma Sciences Society, Institute of Electrical and Electronics. Read more; First Place Paper, 2021 Nuclear Technology R&D Awards. Read more
- **Branko Kovacevic**, doctoral student: J.D. Williams Student Paper Award Competition for Best Poster, Institute of Nuclear Materials Management Annual Meeting
- Department of Defense's Defense Threat Reduction Agency Interaction of Ionizing Radiation with Matter University Research Alliance Annual Technical Review Poster Session, Third Place: **Justin Reiss**, graduate student
- **Pierre-Clément A. Simon**, 2021 graduate: John Schemel Award for Best Paper, ASTM
- **Grant Garrett**, doctoral candidate: 2020 American Nuclear Society Thermal Hydraulics Division Best Paper Award
- **David Reger**, doctoral student: North America Best Paper Award, ASME 28th International Conference on Nuclear Engineering; U.S. Department of Energy Office of Nuclear Energy Integrated University Program Award. Read more
- **Coleman Smith**, third-year undergraduate student: U.S. Department of Energy Office of Nuclear Energy University Program Award. Read more

May named nuclear engineering student marshal

Joshua May served as the student marshal for the Ken and Mary Alice Lindquist Department of Nuclear Engineering at Penn State's spring commencement ceremony on May 7. From York, Pennsylvania, May was a Schreyer Honors Scholar and earned two bachelor degrees, one in nuclear engineering and one in mechanical engineering. He received the President's Freshman Award, the President's Sparks Award, and five scholarships, and worked for Exelon as a strategic engineering intern. He also participated in the Penn State Blue Band. After graduation, May joined Radiant Industries Inc. as a nuclear engineer. May selected **Arthur Motta**, professor of nuclear engineering and materials science and engineering, as his faculty marshal.

Summer Research Experiences for Undergraduates

The Ken and Mary Alice Lindquist Department of Nuclear Engineering hosted twenty-two undergraduate students from across the country for three different Research Experiences for Undergraduates programs during the summer of 2021.

Twelfth Annual Westinghouse Fellows Program Participants
Funded by Westinghouse Electric Company

- **John Barton**, majoring in nuclear engineering at Penn State, advised by Doug Wolfe
- **Shane Evans**, majoring in nuclear engineering at the University of New Mexico, advised by Saya Lee
- **Madison Gitzen**, majoring in nuclear engineering at Penn State, advised by Azaree Lintereur
- **Jake Gutterman**, majoring in nuclear engineering at the University of California, Berkeley, advised by Elia Merzari
- **Jackson Ivory**, majoring in chemical engineering at Brigham Young University, advised by Saya Lee
- **Gibson Prall**, majoring in nuclear engineering at the University of New Mexico, advised by Mia Jin
- **Steven Showalter**, majoring in nuclear engineering at the University of New Mexico, advised by Elia Merzari
- **Abe Weinstein**, majoring in chemical engineering at North Carolina State, advised by William Walters

Drawdown Scholars Research Experiences for Undergraduates Program
Funded by Penn State unless otherwise noted

All participants were advised by both **Melik Sharifironizi** and **Jean Paul Allain**.

- **Brady Dye**, majoring in physics at Howard University
- **Skye Hawthorne**, majoring in environmental science at Wesleyan University
- **Abigail Idiculla**, majoring in civil engineering at Penn State
- **Mariana Duarte**, majoring in computer science at California State University Monterey Bay, sponsored by the department
- **Sherin Khoygani**, majoring in civil environmental engineering at the University of California, Los Angeles, sponsored by the department

Inaugural RAD-Research Program:
Funded by the department

- **Khalifa al-Maktoum**, majoring in nuclear engineering at Penn State, advised by Jean Paul Allain
- **Josue Carrera**, majoring in nuclear engineering at Penn State, advised by Jean Paul Allain
- **Chase Hargrove**, majoring in chemical engineering at Cal Poly Pomona, advised by Jean Paul Allain
- **Rithvik Kundarapu**, majoring in nuclear engineering at Penn State, advised by Mia Jin
- **Robert Ritter**, majoring in nuclear engineering at Penn State, advised by Saya Lee
- **Erik Rominiecki**, majoring in nuclear engineering at Penn State, advised by Mia Jin
- **Sarah Sharif**, majoring in biology at Cal Poly Pomona, advised by Jean Paul Allain
- **Stephanie Strain**, majoring in chemical engineering at Cal Poly Pomona, advised by Jean Paul Allain
- **Johanna Tsai**, majoring in civil engineering at Cal Poly Pomona, advised by Azaree Lintereur

Staff and alumni highlights

Welcoming new staff members

Alyssa Gatone
Undergraduate program assistant; Joined in December 2020

Chelsea Bilyeu
Financial assistant; Joined in April

Allison Singer
Graduate program assistant; Joined in July

Nuclear engineering alumnus named director of Idaho National Laboratory

John Wagner, who earned a master of science in 1994 and a doctoral degree in 1997, both in nuclear engineering at Penn State, was named director of Idaho National Laboratory in December of 2020. INL is a U.S. Department of Energy laboratory that supports each of DOE's strategic goal areas: energy, national security, science, and environment through nuclear energy research and development. It is managed by Battelle Energy Alliance.

Wagner has worked at INL since 2016 and served as associate laboratory director for nuclear science and technology since 2017. Before INL, he worked at Oak Ridge National Laboratory for sixteen years and at Holtec International for two years after completing his graduate degrees. Read more

College of Engineering 40 Under 40 Alumni Award Program

Two nuclear engineering alumni were recognized in the inaugural class of the College of Engineering's 40 Under 40 Alumni Award program, which recognizes graduates who are 40 years old or younger for their early career impact.

Joseph Sinclair (left) is founder of Verde Mantis LP. He earned his bachelor of science in mechanical engineering and nuclear engineering in 2015 and his master of engineering in additive manufacturing and design in 2018.

Robert Salko (right) is a staff research scientist at Oak Ridge National Laboratory. He earned his bachelor of science in mechanical engineering and nuclear engineering in 2006 and his master of science and doctorate in nuclear engineering in 2010 and 2012, respectively. Read more

Historic feat earns alum's team a Model of Excellence

Dillon Figurelle, who graduated with a bachelor of science in nuclear engineering in 2016, is a member of the Reactor Servicing Team for Newport News Shipbuilding that received a 2020 Model of Excellence Award from Huntingdon Ingalls. The team is responsible for loading power units on U.S. Navy ships and was recognized for successfully accomplishing the "historic feat" of loading three power units into two ships in one month. Read more

Letter from the Penn State Nuclear Engineering Society president:

Creating our Legacy

Over the past year, the Penn State Nuclear Engineering Society (PSNES) alumni organization has become highly focused on elevating our mission to support, mentor, and give back to the Penn State nuclear engineering community.

I am proud to say that over these recent months, we've created our best initiative yet: *The Nuclear Sustainability Fund*.

Attending Penn State University Park to earn a nuclear engineering degree is a privilege that not every student has. The vision of our fund is to provide sponsorship opportunities for those across Pennsylvania who cannot afford or are unable to take classes full time at University Park. Support and mentorship of these students will provide a critical link in promoting safe, clean, and reliable nuclear energy across our disenfranchised rural and urban communities. PSNES is forever grateful to the alumni, faculty, and students who have already donated!

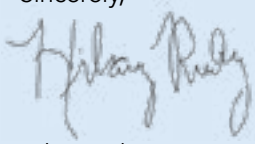
As we're always thinking big here at PSNES, our ultimate goal is to endow this fund for the Ken and Mary Alice Lindquist Department of Nuclear Engineering—and you can help! Learn more about supporting this valuable mission.

If you're interested in catching up with PSNES, check out our new podcast series, "Staying RAD with PSNES," on anchor.fm/psnes. We plan to add plenty of new content in the coming months, as our nuclear alumni share their insights and we explore different aspects of our current nuclear landscape.

PSNES will always be committed to enriching experiences for students and alumni alike and continuing to support the Ken and Mary Alice Lindquist Department of Nuclear Engineering.

I look forward to connecting and working with even more of you in the coming months. We Are!

Sincerely,



Hilary Ruby
PSNES President
NucE '09, '12 M.Eng.

Connect with the Penn State Nuclear Engineering Society on LinkedIn.

Supporting the Ken and Mary Alice Lindquist Department of Nuclear Engineering

Since July 1, 2019, the Ken and Mary Alice Lindquist Department of Nuclear Engineering has received eighty gifts totaling over $86,000. In addition, the department is sharing in a $50,000 fund from Exelon to support student scholarships. We'd like to thank all of our donors for their generous support.

For more information on how to support the department, please contact Melissa Showalter, associate director of major gifts in the College of Engineering, at mus41@psu.edu or 814-865-9031.

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KEN AND MARY ALICE LINDQUIST DEPARTMENT OF NUCLEAR ENGINEERING