Nuclear News

July 2021

In This Issue:

Focus on Health Physics:

RaFTS: The Radiation Field Training Simulator

A critical shift in low-dose radiation research and communication

Steven P. Nesbit
ANS President
2021–2022


REACh™
Enhanced by RADMAN™
RADMAN™
ENHANCED
ACCURACY
CHARACTERIZATION
REACH FOR IMPROVED
ACCURACY
WHAT IF YOU COULD......
Reduce Dose by Taking Less Samples
Directly Measure Gamma Emitting Activity
Minimize Potential Human Errors
Reduce Costs with Highly Accurate Results
WMG
Powered by
CAEN SyS
CAEN Spectroscopy Division
16 Bank St. | Peekskill, NY 10566
914.736.7100
www.wmginc.com

July 2021
Volume 64, Number 8

President's Profile

Feature Articles

Searching for a simulated plutonium source. See page 37.

Every Issue

Departments

Editorial Staff
Director of Publications John Fabian
Publisher/Editor-in-Chief Rick Michal
Staff Writers Susan Gallier, Tim Gregoire, Paul LaTour, Michael McQueen
Copy Editors
Phyllis Ruzicka, David Strutz, Mary Tong
Graphic Design Specialist Chris Salvato
Contributing Designers Jay Bogardus, Lisa Dagley

Advertising & Circulation Staff
Director of Advertising Jeff Mosses
Advertising Production Specialist Erica McGowan

Editorial Advisory Committee
Jess C. Gehin, John G. Gilligan

ANS Officers
President Steven P. Nesbit
Vice President/President-Elect Steven Arndt
Treasurer W. A. "Art" Wharton III
Chairman, ANS Publications Steering Committee
Donald G. Lorentz

Administrative
Executive Director/Chief Executive Officer
Craig Piercy

ANS Headquarters
General Information
askanything@ans.org
708/352-6611 • Fax 708/579-8314 • ans.org

***Nuclear News* Advertising**
708/579-8225 • 708/579-8226
ans.org/advertise • advertising@ans.org

***Nuclear News* Editorial**
708/579-8216 • nucnews@ans.org • ans.org/nn

Nuclear News (ISSN: 0029-5574), Volume 64, Number 8. Published monthly (except during the month of April when issued twice monthly) by the American Nuclear Society, Incorporated, with business, executive, and editorial offices at 555 N. Kensington Ave., La Grange Park, Illinois 60526; telephone 708/352-6611. Subscription rate for 2021 is $670, which includes complimentary electronic access, 1959 to current issue; for subscriptions outside North America, add $80 for shipping and handling. Alternatively, subscription rate is $590 for Electronic Access Only, 1959 to current issue. Single copy price (regular monthly issues) is $52; add $12 for postage and handling if being shipped to address outside North America. Single copy price for annual mid-April Buyers Guide is $125; add $15 for postage and handling if being shipped to address outside North America. Individual ANS members receive *Nuclear News* as part of membership. Replacement copies may be obtained at the single copy price, as long as copies are available. Inquiries about the distribution and delivery of *Nuclear News* and requests for changes of address should be directed to the American Nuclear Society. Allow six weeks for a change to become effective. POSTMASTER: Send change of address orders to *Nuclear News*, American Nuclear Society, 555 N. Kensington Ave., La Grange Park, Illinois 60526, or nucnews@ans.org.

Nuclear News is printed in New Richmond, Wis. 54017, by St. Croix Press, Inc. Nonprofit periodicals postage paid at La Grange, Illinois, and at additional mailing offices.

Comments on a year's worth of the "new" *Nuclear News*

One year ago this month, the "new" *Nuclear News* was introduced. Since then, reader response has been positive. The task of refreshing *NN* was one of the action items of ANS's Change Plan 2020, and many individuals assisted in updating the magazine, including *NN* and headquarters staff, various ANS members, and the Publications Steering Committee.

Since that first new issue was published last July, it has been a learning process for the *NN* staff. Early on, a good number of complimentary messages were received, but there also were suggestions for improvements. One area regarded *NN*'s photo captions, which were in a typeface that was too difficult to read. That flaw was quickly fixed, starting with the August issue.

Another aspect of the new *NN* that drew comments was the disappearance of the Backscatter humor column, which for decades appeared on the last page of the issue each month. That column was cut from the new *NN* because, for years, we had received messages (both through email and in-person discussions with ANS members during national meetings) that Backscatter had passed its prime and was not relevant for today's readers. After the column was dropped, however, we received messages from some readers saying that they had always looked forward to Backscatter. Some questioned, "Where is it?" while others noted that the humor was now missing from *NN*.

Since then, we have realized that it would be good to put some lighter material back into *NN*, but we have not yet found a suitable replacement. So, please help us out. If you have ideas or know of a good scientific humorist who would like to be published monthly, please send him or her our way.

Looking at other areas of *NN*, by now you have become accustomed to the new additions, which include the monthly sections Leaders, Spotlight On . . ., Nuclear Notables, Atoms, Nuclear Trending, and *Nuclear News* Asks.

There also has been a greater emphasis on monthly theme issues. Over the past year, the special sections that *NN* has featured have drawn positive reader response, including "People of Nuclear" (November), "University Programs" (December), "Fusion" (January), "Fukushima: 10 Years On" (March), "Advanced Reactors" (April), and "Economics of Nuclear" (May).

The theme issues remaining in 2021 include the annual "Vendor/Contractor" issue (August), "Probabilistic Risk Assessment" (September), "Plant Maintenance & Outage Management" (October), "Decontamination & Decommissioning" (November), and "Game Changers" (December).

A reminder: Every *NN* issue, going back to the first one, published in July 1959, is available online to ANS members.

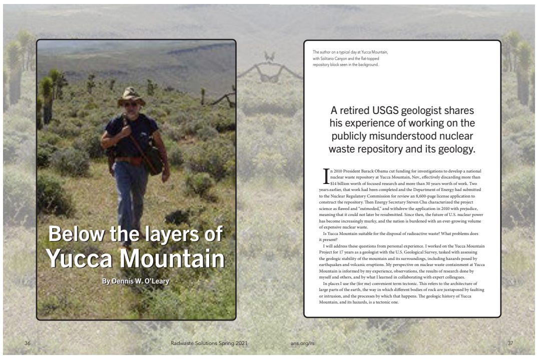
We appreciate your feedback on *NN* to let us know how we're doing. Also, if you have an idea for a special section in *NN*, please drop me a line at rmichal@ans.org.

—Rick Michal, Editor-in-Chief

Readers Write is a new section of Nuclear News *that allows readers to comment more fully on a subject than in a letter to the editor. If you have comments on an issue at length, please send them to rmichal@ans.org.*

Remembering Yucca Mountain

(*Editor's note: We are including in this* NN *issue the following letter that references an article in ANS's* Radwaste Solutions *magazine because we feel that* NN *readers will be interested in the topic.*)



I devoured the article "Below the layers of Yucca Mountain" by Dennis W. O'Leary in the Spring 2021 issue of *Radwaste Solutions*. I worked on the project from 1993 to 2001 as part of the management and operating contractor team. I worked for B&W Fuel Company and its successors. Although I was in waste package development, I had some interaction with geologists because I occasionally went out to what was then the Nevada Test Site as one of the lecturers for public tours. (It was funny to watch the audiences. Before lunch, they were always so interested and engaged. After lunch, they were almost completely passive.)

The article mentioned features, events, and processes (FEPs) that could affect waste isolation, and I remember being in a FEP workshop (in Albuquerque, N.M., maybe). At the end of the workshop, one of the moderators told us to go back to our offices and tell our managers that we needed more money to analyze all the FEPs we had identified. I had plenty of work to do and no confidence that I would get help to study the FEPs, so the last thing I was going to do was tell my manager about new work!

The article also discusses drip shields. I was never much of a proponent of drip shields, especially after a titanium-palladium alloy was chosen. The cost of the alloy would have been prohibitive.

Former secretary of energy Steven Chu had a pivotal role in the Yucca Mountain Project. He may have won a Nobel Prize, but his statement "I think we can do a better job" (also reported as, "I think we can do better") has to be one of the lamest excuses ever given for canceling a project that was on the verge of success. It has been 12 years since Chu's statement, and in that time, I have seen no evidence that a "better job" is actually being done.

To return to the article, it was delightful to read a broad overview of the geologic structure and history of Yucca Mountain and the surrounding area. Thank you for publishing it. I have some interest in geology, and I find it fascinating how geologists use the details of geologic structure (at scales from micrometers to kilometers) to deduce geologic history.

Maybe I will live long enough to see the start of a new project to manage high-level radioactive waste.

Kevin McCoy
Lynchburg, Va.

ASC™
Engineered Solutions

Your trusted valve repair experts

ANVIL SERVICES
An ASC Engineered Solution

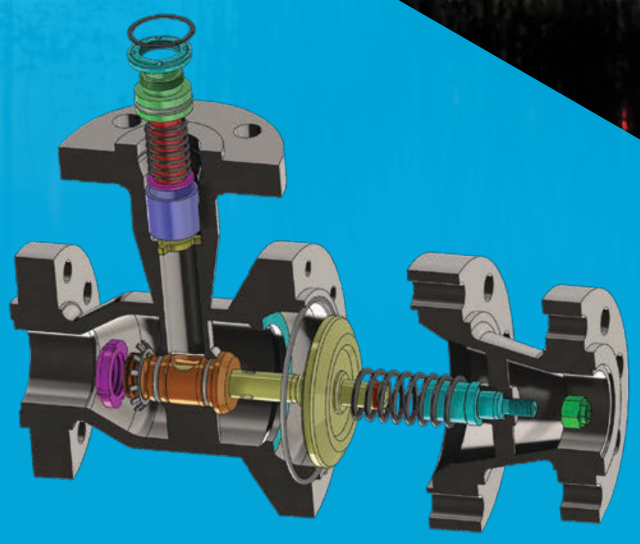
FOR CRITICAL VALVE REPAIRS

Severe Service Valve Trim & Repairs

The ASC Engineered Solutions Anvil Services team provides complete project solutions for critical component repair, replacement parts and field services for both safety and non-safety related applications.

We have you covered with 24/7 service with on-site repair and service. **Your emergency is our emergency.** Forced outage turn-arounds and planned maintenance programs are our specialty. Our 3D scanning and reverse engineering combined with exceptional technical expertise ensures that your parts will be like for like replacements.

To learn more about our valve refurbishment services for the Nuclear Industry call **732-805-4000**.



www.asc-es.com

Building connections that last™

Comments on Conca

I consider the Opinion piece by James Conca (*NN*, June 2021, p. 88) to be very important and extremely informative, and I hope the "powers that be" read it. I have only one criticism. Regarding Fig. 1 and the comments about it, the author mentions 8 rem single dose and 8 rem/yr. These are two completely different concepts. I don't mind 8 rem single dose, and my personal opinion is that we will never be able to identify any measurable effects, detrimental or not, from a single 8-rem dose. However, 8 rem/yr is a different story. To my knowledge, there is no data about 8 rem/yr exposure over many years (which, by the way, is about 25 times greater than annual natural background exposure). The article would stand true without the 8 rem/yr comment. Excellent article!

Nicholas Tsoulfanidis
Reno, Nev.

The sharp break of James Conca's dose response curve is unnatural (*NN*, June 2021, p. 88). A more realistic curve would start at the origin as a second-degree polynomial (parabola) and gradually become linear at higher doses. Mathematically, this would be a properly chosen and placed section of a hyperbola. Such a shape would show zero probability of adverse effects (zero slope) at low doses, while smoothly merging into the known linear relation between dose and harm at high doses.

John Tanner
Idaho Falls, Idaho

James Conca responds: There were some good catches on my June opinion piece in *NN*. One pointed out that Fig. 1 says, "However, small doses of radiation, <10 rem(cSv)/yr, appear to be easily handled by cellular repair mechanisms . . . ." I should have clarified that rem/yr is a dose rate, although a total of <10 rem/yr would necessitate actual doses much smaller at any specific time over that period. For the other catch about the sharp break in the dose response curve in Fig. 1 being unnatural and should instead be a second-degree polynomial, I can only say that this figure was not supposed to be mathematically rigorous, just illustrative. But I don't think the change in curve shape would be smooth in any case. It is basically unknown at this point and has more to do with the dose getting to the point where it overwhelms the immune system, at about 20 rem acute. It also has to do with the risk decreasing with decreasing dose until it disappears below the everyday risks of life, also not a smooth curve but just disappearing into the noise. The problem is when the risk drops below where it can be determined relative to ordinary risks, then prediction is meaningless, because that risk has no effect on the system; it is just theoretical. That is why we have never seen effects from doses less than 10 rem, even from Japanese bomb survivors.

Good job, *NN*

I have worked on nuclear fusion research for decades. The January issue of *Nuclear News,* with the theme of fusion, is excellent. I also appreciate the great April issue on advanced fission reactors.

Thomas J. Dolan
Ionia, Iowa

I enjoyed reading the excellent articles in the May issue of *Nuclear News.*

Jerry Cuttler
Thornhill, Ontario

I really like the new formatting *of Nuclear News*!

Art Wright
Algonquin, Ill.

Beauty and the Beast

An idea quite lovely is energy renewable.
It sings to the soul and so should be doable.
Sun and wind to our rescue surely will come,
the wrath of climate's change to save us from.

If only the wind we could contain in a vessel,
on our windmills to blow in the still of cold night,
and the sun's rays we could store in a bottle,
on our panels to fall when night blocks their light.

Will science soon come like a shining bright knight,
to rid sun and wind of their intermittent plight?
Can days of their power be stored at low cost,
or will their allure with time be lost?

On nuclear power must we learn to rely?
No greenhouse gas does it emit to the sky.
And it's there day and night, in heat and cold,
even with reactors a half century old.

Elmer E. Lewis
Evanston, Ill.

Radiation is all around us

Like most cliches, it's true. Radiation is a natural part of life in this universe, and its applications in science, medicine, and technology continue to grow.

100 years of isomers

Otto Hahn and Lise Meitner collaborated to discover nuclear isomers—nuclei with the same number of protons and neutrons arranged in a higher-energy state—just over 100 years ago. The energy states of some isomers make them ideal for practical applications.

Technetium-99m is an isomer of Tc-99 that emits a single 141-keV gamma ray with no accompanying beta particles. The first Tc-99m generator was developed in 1957 at Brookhaven National Laboratory, and today Tc-99m is used in about 20 million medical applications each year. Its six-hour half-life is long enough for a scan to be completed, but short enough to decay away quickly.

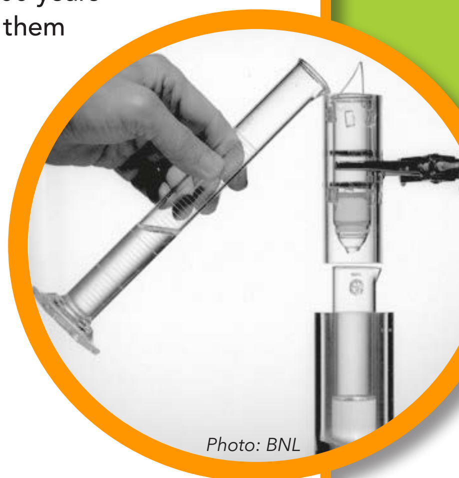


Photo: BNL

AMERICIUM

Am

95

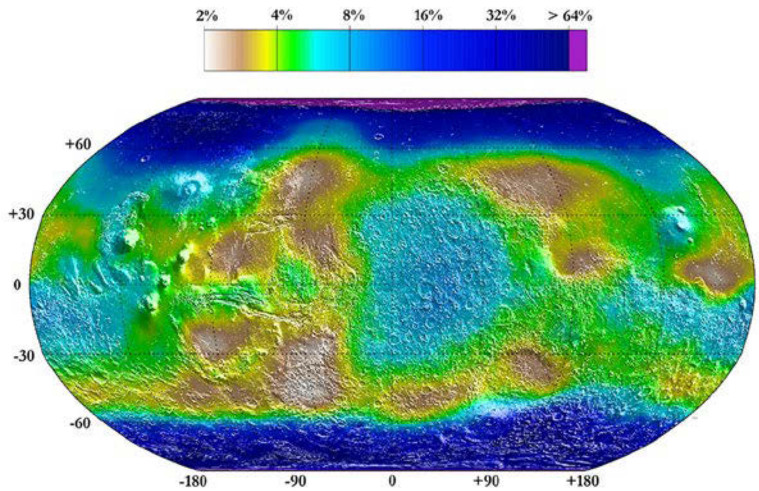
Americium-242m is a rare higher-energy isomer that is more stable than lower-energy Am-242. It stores an energy of 49 keV, has a half-life of 141 years, and releases its energy when excited by photons of just 4 keV, making it a candidate for nuclear batteries proposed for space power applications.

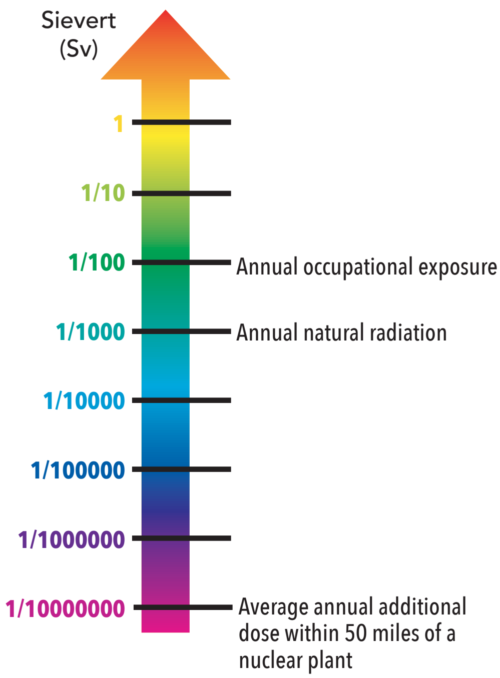
Martian spectrometry

A gamma-ray spectrometer (GRS) was deployed on NASA's 2001 Mars Odyssey mission to identify elements in the Martian soil by detecting scattered neutrons and gamma rays from the surface of the planet while in orbit. The GRS was equipped with a neutron spectrometer and a high-energy neutron detector capable of detecting hydrogen up to a depth of 1 meter, allowing scientists to infer the presence of water ice.

Source: NASA

LOWER LIMIT OF WATER MASS FRACTION ON MARS





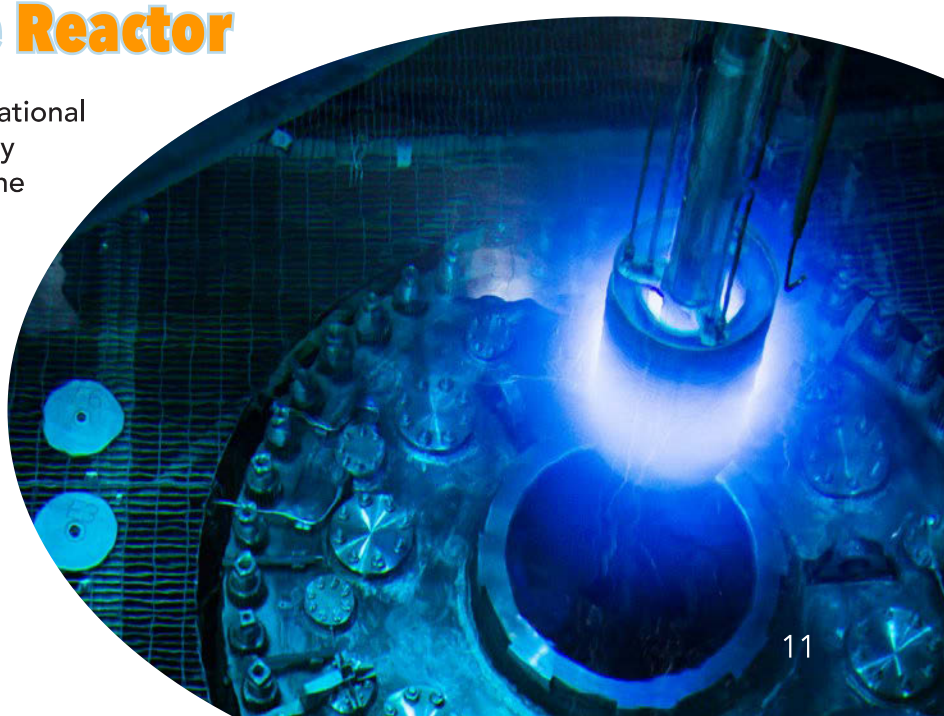
Orders of magnitude

The sievert (Sv) was introduced in 1975 as the SI unit of effective dose and an alternative to the rem, which is an abbreviation of Roentgen equivalent man (1 Sv = 100 rem). Typical annual radiation exposure for Americans is about 0.0062 Sv (6.2 mSv), or 620 mrem, with roughly half of that dose coming from natural background radiation. According to the Nuclear Regulatory Commission, people living within 50 miles of a nuclear power plant receive an average additional radiation dose of just 0.01 mrem (0.0000001 Sv) per year.

Sources: U.S. Department of Health and Human Services and NRC

High Flux Isotope Reactor

HFIR began operating at Oak Ridge National Laboratory in 1966 as a source of heavy isotopes. Its primary mission now, as the United States' highest flux reactor-based neutron source, is providing thermal and cold neutron beams and instruments for neutron scattering research. HFIR also produces isotopes of heavy elements, such as californium-252, and a number of isotopes for medical applications.



Refueling HFIR in July 2015.
(Photo: Genevieve Martin/ORNL)

Communicating about radiation in the 21st century

By Paul A. Locke

It might seem odd to begin a discussion about radiation risk communication with a title that references the 21st century. Simple math tells us that more than 20 percent of the 21st century is in our rearview mirror. Still, today we are relying on many of the concepts and ideas about communication that were developed decades ago. Using dated techniques for outreach about radiation hinders efforts to engage communities and the public in a discussion about the risks and benefits of technologies that use radiation sources.

Several years ago, I visited the Hanford Site's B Reactor. I also toured an operating nuclear power plant that is currently part of the U.S. fleet, and I have learned about the design and operation of advanced small modular reactors. The evolution in reactor designs represented by these three technologies demonstrates that a culture of innovation and research delivers success. The nuclear industry is now, and continues to be, forward-looking as power generation, cleanup, and worker protection become advanced and are made safer, more efficient, and ready for the future.

Paul Locke, an environmental health scientist and attorney, is an associate professor in the Department of Environmental Health and Engineering at the Johns Hopkins Bloomberg School of Public Health in Baltimore, Md.

It is past time for radiation risk communication to jump on board the innovation bandwagon, and there are many places we could begin. Using social media tools or taking advantage of other new channels of information might first come to mind. What I have found, though, is that the major challenges in moving risk communication forward are conceptual.

I think that the best place to start this transformation is to unpack the phrase "radiation risk communication" and look at what it means in practice. What is really needed when we engage in conversations about radiation with the public? While a complete answer to this question cannot be covered here, we can start by keeping four key factors in mind.

First, reject the idea that the goal of communication is to fill the gaps that might exist in others' knowledge about radiation. This is called the "deficit reduction" model of communication, and it is based on the idea that public skepticism and lack of support are due to inadequate understanding of the "scientific facts." If you are a scientist, or engineer, or think like one, you have likely been trained to approach discussions this way. Unfortunately, this model has not been successful in communicating with most stakeholders about radiation and, I would argue, does more harm than good.

Second, recognize that communication is a two-way street. It is important to listen first and learn what issues are most important to the audience with which you want to communicate. A listen-first philosophy will usually reveal how and why radiation issues have

21st-century radiation risk communication will require continuing efforts to support innovation and new knowledge about how to communicate in the future.

arisen and what perceptions about radiation exist. In some cases, it might be that radiation is tethered to other issues, such as concern for property values, or social justice, and/or civil rights. You will also likely discover that the public's views about the risks of radiation are closely tied to the radiation source. People generally discount the impacts of naturally occurring radiation yet would dread the same type and amount of radiation if it came from a man-made source or a disposal site.

Active listening leads to the third, and most important, factor. The linchpin of successful communication is trust. Trust building should be the major goal of any communication dialogue. It means having a communications plan about how to engage effectively and continuously with stakeholders in a transparent and open way. Creating a level playing field that facilitates discussion and interaction is probably the best way to build a relationship founded on trust. Once trust is established, the fourth factor comes into play—discussing the benefits associated with nuclear technologies and how benefits and risks should be weighed.

Even after we make these conceptual adjustments, 21st-century radiation risk communication will require continuing efforts to support innovation and new knowledge about how to communicate in the future.

Legislation recently signed into law has the potential to improve risk communication by supporting research centered around one of the most difficult communication challenges—low-dose radiation exposure and its effects. This law requires that the National Academies of Sciences, Engineering, and Medicine form a committee to develop a long-term strategy for low-dose radiation research. A key component of that strategy is to develop a research agenda that supports education and outreach activities that will promote understanding of low-dose research. If done correctly, this study could help revitalize radiation risk communication.

Low-dose radiation is one of ANS's Nuclear Grand Challenges. ANS Position Statement 41, which addresses the health effects of low-dose radiation, states, "Radiation risk communication research and outreach, and a robust social science research program, should be prioritized to help promote science-informed perspectives regarding the risks and benefits of nuclear and radiological technologies in all industries."

While we celebrate the next generation of technologies that use radiation for the public good, let's make sure our communications about radiation's risks and benefits are not left behind. Exposure to radiation can create health risks. It is incumbent on radiation professionals to explain these risks and to be attentive to the issues that they raise. It is equally important to tell the story of how these risks have been, and will continue to be, reduced, and how technologies that use radiation benefit our world.

Spotlight On . . .

The ANS Isotopes & Radiation Division

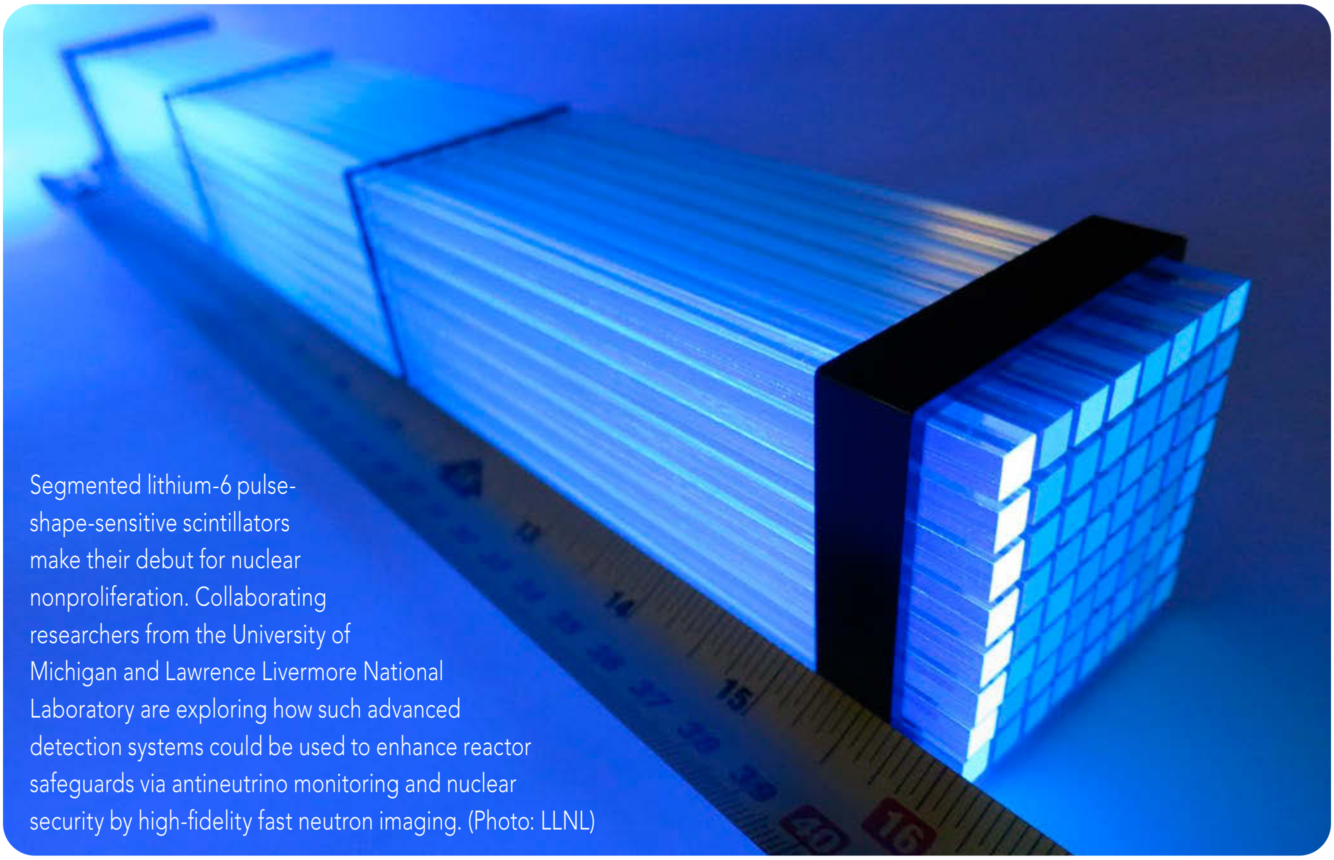
By the IRD Executive Committee

On November 20, 2019, the American Nuclear Society Board of Directors unanimously approved the reunification of the Biology & Medicine Division into the Isotopes & Radiation Division with an updated mission statement, technical committee list, and bylaws. BMD grew out of IRD in 1987, although the two have always been closely linked in technical interest and have historically retained a great degree of overlap in their executive committees. The merged division has retained the Isotopes & Radiation Division name, being one of the original divisions of ANS.

While the COVID-19 pandemic has impacted implementation of a new vision, the combination of the two divisions represents a streamlining. It reduces the burden to support two separate divisions with the necessary program chairs and executive committee membership—an issue that previously drew away from the ability to operate high-quality technical sessions and provide professional leadership on important topics and position statements. We believe that recognizing and embracing the fact that IRD operates a broad set of committees allows the combined division to be technically stronger going forward. We do not believe that every subgroup requires a separate, named division; all too often have we seen a small, passionate group come in for a year or two only to fade, leaving ANS with a poorly supported division. Rather, strengthening the technical committees within IRD will be a key to success and bringing value to our membership by (1) putting on outstanding technical content as part of ANS national meetings and topical meetings and (2) helping to address technical and scientific matters affecting nuclear science.

Following the merger, IRD continues to focus on fundamental and applied technology related to the production and use of isotopes, nuclear methods of analysis, and the measurement of radionuclides and ionizing radiation. Specific areas of interest to IRD members include:

- Production, characterization, and utilization of isotopes for medicine and industry using reactors and alternate sources of production.
- Nuclear methods for material characterization, including ionizing radiation beam techniques and activation analysis.
- Radiometric and radiochemistry techniques for quantitative analysis, nuclear data measurements, and the study of radionuclide behavior in the environment.
- Measurement techniques and applications as they apply to nuclear security, including treaty



Segmented lithium-6 pulse-shape-sensitive scintillators make their debut for nuclear nonproliferation. Collaborating researchers from the University of Michigan and Lawrence Livermore National Laboratory are exploring how such advanced detection systems could be used to enhance reactor safeguards via antineutrino monitoring and nuclear security by high-fidelity fast neutron imaging. (Photo: LLNL)

monitoring and verification, nuclear nonproliferation, safeguarding nuclear materials, and nuclear forensics.

■ The application and development of nuclear technology for the life sciences, as well as the impact of such technology on society, including radiation beam therapy, medical physics, radiographic and radioisotope imaging, radionuclide biological tracers, instrumentation, radiopharmaceutical synthesis and radionuclide production, dosimetry and effects of ionizing radiation, and other related subjects.

A short history

Formed in 1959 as one of the first divisions of ANS, IRD later incorporated, in 1975, the Aerospace & Hydrospace Division. Historically, IRD has focused on topics devoted to applying nuclear science and engineering technologies involving isotopes, radiation applications, and as-sorted equipment in scientific research, development, and industrial processes. IRD members' interests lie primarily in education, industrial uses, biology, medicine, and health physics. Our division's committees include Analytical Applications of Isotopes and Radiation, Biology and Medicine, Radiation Applications, Radiation Sources and Detection, and Thermal Power Sources.

As mentioned above, IRD and BMD merged back together in 2019. BMD formed as a technical group in 1980 and split off as a separate division in 1987. Prior to the reintegration, BMD focused on the application and development of nuclear technology for the life sciences, as well as the impact of such technology on society. Areas of interest included neutron, photon, and charged-particle applications; dosimetry; radiographic and radioisotope imaging; radionuclide tracers; instrumentation; radiopharmaceutical synthesis and radionuclide production; bone and tissue dosimetry; effects of radiation exposure; and related subjects.

Spotlight continues

IRD has maintained approximately 850 members, while BMD's membership was around 400. Student members constitute about one-quarter of the members. Recognizing overlap between IRD and BMD, it is anticipated that IRD will stabilize at 1,000–1,200 members.

When joining ANS, new members must choose which divisions to be a part of, and IRD hopes the merger simplifies this choice and that there is a clear case for those who practice in the areas covered under IRD's charter. IRD also hopes to continue to attract young members and student members. IRD's goal is to increase membership and entice our members to actively participate at the national level.

IRD operates 10 technical committees:

1. Industrial Measurements and Applications
2. Nuclear and Atomic Analysis
3. Radiation Effects
4. Transuranics
5. Safeguards, Forensics, and Nonproliferation
6. Research Reactors
7. Isotope Production
8. Neutron Sources, Neutron Beams, and Applications
9. Gamma and Neutron Imaging Applications
10. Development and Applications of Nuclear Technology for the Life Sciences

IRD technical committees

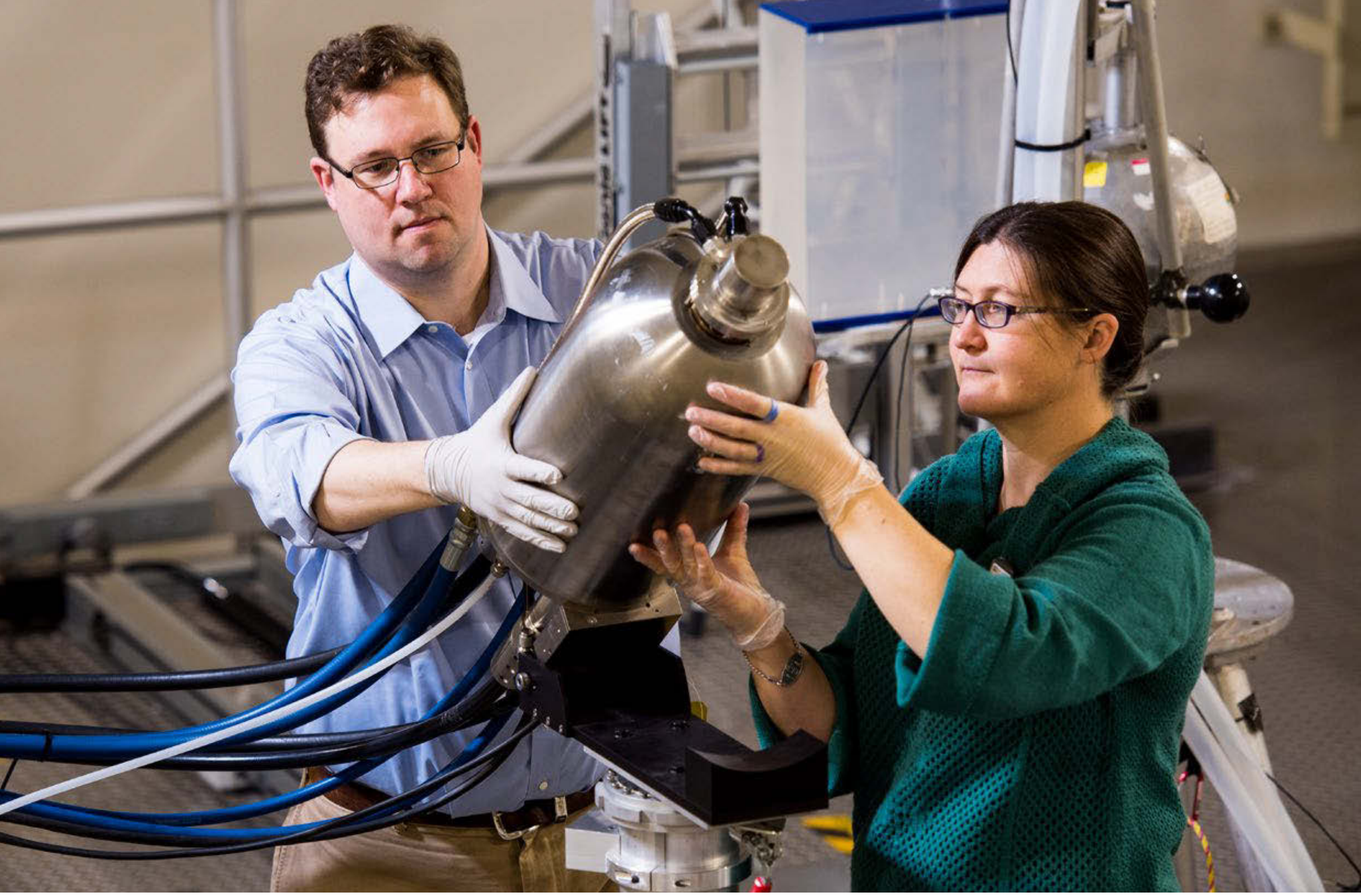
IRD's technical committees are the most important component of the division. Along with the program chair and the assistant program chair, these groups coordinate the technical program for the division and establish collaborations with other technical divisions.

IRD invites individuals who are excited about promoting work in the division's technical areas (see sidebar) to reach out and actively participate in the technical committees. As ANS adapts to a new structure for programs at national meetings, IRD wants to make sure that we actively cover these areas, and that can only happen with active participation of its members. Please contact any member of the IRD executive committee or program committee if you are interested in leading or helping with activities in a technical committee.

Conferences

In addition to hosting sessions at the ANS Annual and Winter Meetings, IRD supports a range of technical meetings. Notably, the Methods and Applications of Radioanalytical Chemistry (MARC) conference is an IRD-sponsored meeting with very high visibility. Since MARC I in 1987, this conference series has become the major international forum for discussion of advances in radioanalytical chemistry and its applications, despite typically being held in locations somewhat remote for many participants. A variety of topics are covered in the scientific program, including environmental radioactivity measurements, activation analysis, biology and medical applications, radiation detectors and instrumentation, nuclear proliferation prevention and safeguards, education, and mass spectrometry methods for detecting radioactive materials.

ANS, through the IRD and the Northern California Local Section, again serves as sponsor for the upcoming MARC XII, which will be held in Kailua-Kona, Hawaii, April 3–8, 2022. Check out the website for more information: www.marcconference.org.



The 14-MeV neutron generator at Pacific Northwest National Laboratory's Low-Scatter Facility is used to conduct nuclear data experiments and produce radionuclides, such as argon-37, for national security R&D applications. (Photo: PNNL)

Awards and scholarships

IRD is committed to recognizing scientific excellence and providing opportunities to students. IRD has several established awards and is very pleased to have a new graduate student scholarship created last year, thanks to a major gift from the Gozani family. Following is a list of IRD's awards:

- The **James R. Vogt Radiochemistry Scholarship**
- The **Radiation Science and Technology Award**
- The **Mishima Award** (sponsored by IRD in cooperation with the Materials Science & Technology Division)
- The **Gozani Family Graduate Scholarship**

For more information, please visit http://ird.ans.org/honors-awards/.

Research

The research fields related to IRD are making rapid advancements. Some emerging research areas with high impact include the following:

- **Medical physics and isotope production** are areas of broad interest that IRD can leverage, with the right technical committee support, both to put on excellent plenary discussions that inform the broad audience of ANS as well as to host robust technical sessions. For instance, human trials of FLASH radiotherapy (>40 Gy/s) at the Cincinnati Children's/UC Health Proton Therapy Center have begun, aiming to treat bone metastases using the 250-MeV proton beam from a Varian ProBeam particle accelerator. Broader research is planned to examine treatment of other metastatic cancers in the hope of killing cancer with reduced side effects.
- **Radiography and tomography** are essential nondestructive analytical methods. Research reactors are great assets to nuclear science and engineering, education, research, and industrial

Spotlight continues

applications. A collaboration between Ohio State University and Lawrence Livermore National Laboratory, sponsored by the LLNL Laboratory Directed Research and Development Program, is developing fast neutron computed tomography (nCT) as part of an image/data fusion strategy, along with ultrasound and X-ray CT imaging modalities. The goal is to develop multimodal characterization methods to identify and eliminate manufacturing defects in additively manufactured parts and ensure quality control.

■ IRD members are actively involved in the development of technology to support **nuclear nonproliferation efforts**, which are an essential element of the strategy to maintain and expand the use of nuclear power. Vanguard research ranges from utilizing antineutrinos to monitor nuclear reactor operation, to using radioactive noble gases to monitor clandestine nuclear activities around the world, to advancing radiation detection and imaging technology for improved detection and characterization of nuclear material. Technical advances in this area have a significant impact on global security and stability.

■ **Nuclear safeguards** rely on a diverse set of technologies. One of the key technologies is the detection of penetrating radiation (gamma rays and neutrons) from special nuclear materials with high efficiency and specificity. IRD members are involved in developing novel radiation detector materials and designs that allow for improved energy resolution in gamma ray detection while keeping costs low. There is a vibrant effort to develop better fast neutron detection materials in techniques, where a key challenge is the ability to discriminate neutrons from their accompanying gamma rays. Large gains in signal detection in complex backgrounds can be achieved by the use of imaging techniques, which are based on methods such as coded apertures, Compton scattering, and double neutron scattering. These imaging systems are also being miniaturized for handheld and drone deployments, and algorithms are being developed to better interpret the data from individual detectors and distributed detector arrays.

■ Members of IRD have had a rich history of applying radioanalytical chemistry to support **forensic investigations**. This includes traditional criminal forensic applications like applying neutron activation analysis for the determination of trace elements in gunshot residue, nuclear archeometry techniques for elucidating the production and geographic history of antiquities using trace element profiles and radiochronometry, and more recently, nuclear forensics for the identification of nuclear and radioactive materials recovered from outside of regulatory control. Nuclear forensics relies on the technical examination of materials to uncover connections between materials, people, places, and events. A significant area of research to assist in better interpreting nuclear forensic data involves studying how the chemical, physical, and isotopic characteristics change as materials transit the fuel cycle.

We are looking for experts in:

- Enrichment Technology
- Fusion Energy
- Isotopes
- Modeling and Simulation
- Nuclear Energy and Fuel Cycle Technology
- Nuclear Security

Find your future at: jobs.ornl.gov

Oak Ridge National Laboratory

U.S. Department of Energy

ORNL is an equal-opportunity employer. All qualified candidates, including protected veterans and individuals with disabilities, are encouraged to apply. ORNL is an E-Verify employer.

Smoldering over popular media's coverage of Chernobyl

By Tim Gregoire

No matter the discipline, reporting on technical issues for a mass audience is fraught with pitfalls. To make the subject understandable to the layperson, authors make generous use of analogies, which are inherently incomplete and tenuous, like a stone house being built on swampland.

Likewise, in an effort to garner as many clicks or views as possible, reporters and news outlets will often resort to sensationalism, making the news being reported more dramatic than it is. (To be fair, those supplying the news can also be guilty of sensationalism in their hunger for media coverage.)

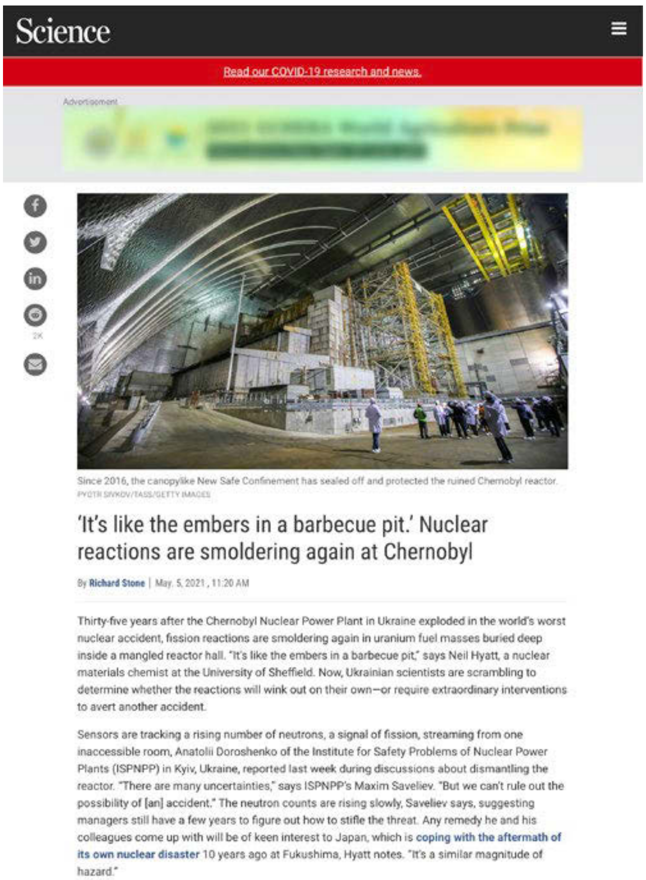
This was evident recently when *Science*, generally a respected academic journal, reported on an increase in neutron activity detected within an inaccessible room at the damaged Chernobyl nuclear power plant. The wider media quickly picked up the story, amplifying its catastrophic message.

The *Science* article was based on findings that Ukraine's Institute for Safety Problems of Nuclear Power Plants (ISPNPP) presented during the International Conference on Nuclear Decommissioning and Environmental Recovery, held in Ukraine in April. The institute, which is part of the National Academy of Sciences of Ukraine and tracks the state of the Chernobyl structure, shared information on the condition of the structure and the effects of the protective New Safe Confinement (NSC) on the building and the nuclear materials within it.

The ISPNPP acknowledged that an increase in neutron flux density was observed near Room 305/2, but noted that the increase did not exceed safety measures and did not indicate criticality. What's more, the ISPNPP had predicted as early as 2015 that the flux would increase after the NSC was put in place. That is because models of fissile materials within the structure had shown that the NSC would prevent precipitation from entering the structure and that water within Room 305/2 would be lost.

It is therefore likely that the increase in detected neutrons is simply the result of more neutrons reaching Chernobyl's monitoring system from the loss of the water, which had previously shielded the radiation. According to Chernobyl NPP, the sensors tracking the neutrons "show constant values in all premises with no trends to rise, and the current levels do not pose threat of self-sustained chain reaction of fission."

That, however, did not stop *Science* and other news outlets from making proclamations about "smoldering" fission reactions and raising the specter of runaway nuclear reactions and explosions.



Science

Read our COVID-19 research and news.

Advertisement

Since 2016, the canopylike New Safe Confinement has sealed off and protected the ruined Chernobyl reactor.
PYOTR SIVKOV/TASS/GETTY IMAGES

'It's like the embers in a barbecue pit.' Nuclear reactions are smoldering again at Chernobyl

By Richard Stone | May. 5, 2021 , 11:20 AM

Thirty-five years after the Chernobyl Nuclear Power Plant in Ukraine exploded in the world's worst nuclear accident, fission reactions are smoldering again in uranium fuel masses buried deep inside a mangled reactor hall. "It's like the embers in a barbecue pit," says Neil Hyatt, a nuclear materials chemist at the University of Sheffield. Now, Ukrainian scientists are scrambling to determine whether the reactions will wink out on their own—or require extraordinary interventions to avert another accident.

Sensors are tracking a rising number of neutrons, a signal of fission, streaming from one inaccessible room, Anatolii Doroshenko of the Institute for Safety Problems of Nuclear Power Plants (ISPNPP) in Kyiv, Ukraine, reported last week during discussions about dismantling the reactor. "There are many uncertainties," says ISPNPP's Maxim Saveliev. "But we can't rule out the possibility of [an] accident." The neutron counts are rising slowly, Saveliev says, suggesting managers still have a few years to figure out how to stifle the threat. Any remedy he and his colleagues come up with will be of keen interest to Japan, which is coping with the aftermath of its own nuclear disaster 10 years ago at Fukushima, Hyatt notes. "It's a similar magnitude of hazard."

The Chernobyl site in 2017 following the placement of the NSC structure. (Photo: European Bank for Reconstruction and Development)

It also did not help that *Science* quoted nuclear materials chemist Neil Hyatt, of the University of Sheffield, as saying the fuel materials could be compared to "embers in a barbecue pit." As pointed out by ANS member Ben Forget, a professor in the Department of Nuclear Science and Engineering at the Massachusetts Institute of Technology, it is an analogy more suitable to describing decay heat than criticality. In the context of the article, however, it invokes images of a barely contained fire, ready to reignite at any moment.

Science also quotes ISPNPP researcher Maxim Saveliev as saying, "We can't rule out the possibility of [an] accident," but then provides no context on what that risk factor is or what its severity would be, other than to say that there's "no chance of a repeat of 1986." No scientist or engineer, given a certain situation, would ever say there is a zero risk of something happening, however improbable.

To use another analogy, there is a possibility of being struck by lightning as soon as we leave our house, but we know the chances are too low to prevent us from ever stepping foot outside. And it definitely is not newsworthy.

Tim Gregoire is a staff writer for Nuclear News *and the editor of ANS's* Radwaste Solutions. *His focus is on waste management and decommissioning.*

ANS signs on to letter supporting reintroduction of ANIA

The American Nuclear Society was among 24 nuclear-related companies and organizations that signed a letter urging Senate sponsors of the American Nuclear Infrastructure Act (ANIA) to reintroduce and advance the legislation. The signees represent a broad range of nuclear supporters from the industrial, nonprofit, and advocacy sectors. The letter was sent to Sens. Shelley Moore Capito (R., W.Va.), Mike Crapo (R., Idaho), John Barrasso (R., Wyo.), Cory Booker (D., N.J.), and Sheldon Whitehouse (D., R.I.). Barrasso was the original sponsor of the bill, while Whitehouse, Crapo, and Booker were original cosponsors.

According to the June 1 letter, the ANIA would direct the Nuclear Regulatory Commission to continue to modernize its regulatory review processes, which would help enable nuclear energy to deploy at a rapid enough scale to support decarbonization. In addition, preemptively reviewing Department of Energy sites for demonstration reactors could help companies partner with the national laboratories to test out innovative concepts, including advanced methods of manufacturing and construction.

The ANIA also includes empowering the NRC to engage with and help develop other countries' regulatory agencies, which strengthens international safety and security standards. Furthermore, permitting investments by allied countries strengthens the United States by building long-term partnerships that could lead to deploying U.S. reactors in other international markets. Both provisions take a long-term view on the role the United States should play in the global nuclear industry, the letter states.

The ANIA also has provisions that would provide for a Superfund cleanup at abandoned mine sites, including sites on tribal land, and require health assessments for certain sites on tribal land.

"The innovative programs established in this bill support currently operating nuclear reactors and the next generation of reactor technologies," the letter reads. "The American Nuclear Infrastructure Act is an important next step in modernizing our regulatory infrastructure and rebuilding our nuclear industrial capabilities."

In addition to ANS, the other signees were ARC Clean Energy, BWX Technologies, the Center for Climate and Energy Solutions, the Clean Air Task Force, ClearPath Action, the Climate Coalition, the Edison Electric Institute, Energy Northwest, Framatome, GE Hitachi Nuclear Energy, Generation Atomic, Holtec International, Kairos Power, the Nuclear Energy Institute, the Nuclear Innovation Alliance, Nucleation Capital, Orano USA, TerraPower, TerraPraxis, Third Way, the U.S. Chamber of Commerce Global Energy Institute, the U.S. Nuclear Industry Council, and X-energy.

ANS PRESIDENT'S COLUMN

Another year, another ANS president

Steven P. Nesbit
president@ans.org

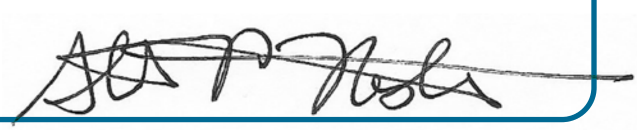
It's like clockwork. In June of every year, the American Nuclear Society brings in a new elected leader for the next 12 months. I'm Steve Nesbit, the latest in a line of distinguished (and maybe a few not so distinguished) nuclear professionals who have had the honor and privilege of serving as ANS president.

This is your lucky day. Everything you ever wanted to know about me, but were afraid to ask, is in another article in this issue of *Nuclear News* (page 28). Instead of plowing that ground again here, I'll take advantage of my monthly column to cover a few other topics that are hopefully of value.

First of all, thank you for being a fellow nuclear professional and supporting our amazing technology on a personal level by belonging to ANS. Perhaps some of you may view your membership on a purely transactional basis—you get certain benefits that outweigh the cost of membership (which may even be zero, if you have a benevolent employer). However, I think most of you belong to ANS, at least in part, because you feel the human urge to identify with a group and accomplish things together. What it really means to be a nuclear professional is an area of significant interest to me. I have my ideas, and I'll be listening to what you have to say about it over the next year. Maybe I'll revisit the issue next June in my final column as president.

What do I plan to accomplish during my year at the helm of ANS? Looking inward, I want to build on the work of my predecessors and the ANS staff to further improve and strengthen the Society's infrastructure, which has already experienced significant change over the past few years. Looking outward, I want to collaborate with other organizations, policymaking bodies, and individuals to improve the environment for nuclear technology, both nationally and internationally. Those are general goals, and I will be speaking and writing about the specifics over the months to come.

Finally, I want to acknowledge the contributions of my predecessor in this office, Mary Lou Dunzik-Gougar, and offer her my thanks for her service during a most challenging pandemic year. She made the best of a bad situation, and, along with ANS Executive Director/CEO Craig Piercy, she provided the leadership ANS needed to continue as the premier organization for those who embrace nuclear science and technology.



Nuclear Trending continues

ANS holds launch party for virtual field trip to space

ANS celebrated the launch of the newest Navigating Nuclear virtual field trip, "Nuclear Frontiers: Powering Possibility," with a special watch party held on May 19. The video, which was viewed more than 70,000 times in the first week alone, explores the amazing ways that nuclear science is fueling earthly innovation and deep space exploration.

The virtual field trip is part of the Navigating Nuclear: Energizing Our World program, a partnership between ANS, Discovery Education, and the U.S. Department of Energy that has reached more than 1.5 million K-12 students. "I'm especially appreciative of these curriculum materials, having been a K-12 science teacher myself in a previous life," ANS President Mary Lou Dunzik-Gougar said in her opening remarks during the watch party. "I've been in the K-12 classroom, and I recognize the importance of roles that teachers play in students' lives and how hard it can be as a K-12 teacher to be an expert in all these different fields. So, I feel that these curriculum materials are so valuable for that reason."

Virtual Field Trip continues on page 26

Nuclear Notables—An early history of I&R events

1895
Wilhelm Conrad Roentgen discovers X-rays.

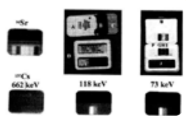
1898
The discovery of radium is reported by Marie and Pierre Curie.

1899
Ernst Rutherford discovers that radioactivity from uranium has at least two different forms, which he calls alpha and beta rays.

1913
Hans Geiger introduces his radiation detector.

1915
The British Roentgen Society proposes standards for radiation protection of workers.

1920
The American Roentgen Ray Society forms the first X-ray protection committee.



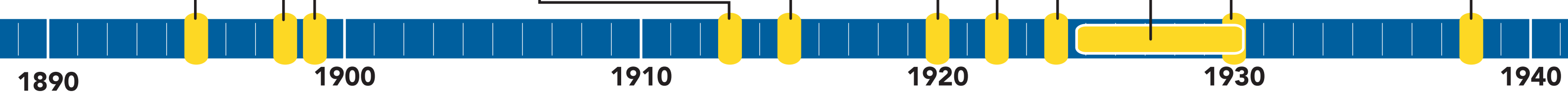
1922
Film badges are developed to measure radiation exposures.

1924
Arthur Mutscheller proposes the first radiation tolerance dose for use as a guide to limiting exposure of an individual to radiation.

1925–1930
400,000 bottles of Radithor, a potion containing radium that was said to cure various health issues, are sold in the United States.

1930
Charles Lauritsen develops high-voltage X-ray machine for radiation therapy.

1938
Otto Hahn is the first to split the uranium atom, opening up the possibility of a chain reaction.



Radiation and the objective perception of risk

Craig Piercy
cpiercy@ans.org

This month's *Nuclear News* is dedicated to the people and technologies engaged at the intersection of radiation and humanity. As good-news stories go, the medical and industrial use of ionizing radiation is probably one of the most underappreciated narratives of modern times. Every day, nuclear technology saves hundreds of lives in the United States and around the world. Sometimes the benefits are obvious, as when a patient with an inoperable cancer is successfully treated with lutetium-177, or the americium-241 in a household smoke detector enables a family to escape a home fire without injury. In other instances, the benefits are completely hidden from the average person's view, like the millions of cases of bacterial infections avoided each year by the irradiation of food and cosmetics products.

In an ideal world, our federal and state governments would base their policies on the use of radiation and radiological material purely on the principles of risk assessment and cost-benefit analysis. Unfortunately, we do not live in an ideal world.

In reality, our inconsistent standards and policies cause us to misallocate public resources, sometimes on a massive scale. Consider this: Each year, roughly 1.7 million Americans are diagnosed with cancer. Roughly one-quarter of them will experience financial distress because they cannot fully afford the prescribed treatment in our current health care system. Yet, the Environmental Protection Agency decided a few years back to change the Superfund radiation cleanup standard from 15 mrem per year to 12 mrem, basically adding $100 billion—roughly $58,000 per new U.S. cancer patient—to the estimated cleanup tab for Department of Energy defense sites, with no proof that it would save a single life.

For decades, ANS has been an active voice for responsible radiation regulation in the United States, but for much of that time, it has felt like a lonely quest. That is changing. In 2016, ANS founded the Source Security Working Group (SSWG), an alliance of organizations that includes the International Irradiation Association, the International Source Suppliers and Producers Association, the Gamma Industry Processing Alliance, the American Association of Medical Physicists, and the American Society for Radiation Oncology. SSWG's mission is to ensure that the continued safe use of radiation-based technologies is not compromised by one-sided, fear-based policies, and the group has been instrumental in educating key policymakers on the beneficial applications of radiation, as well as amending or defeating legislative and administrative proposals that would have unnecessarily curtailed its use in medicine and industry.

Last fall, ANS updated its position statement on low-dose radiation exposure. It states that the practice of keeping doses as low as reasonably achievable (ALARA) "is intended to be an optimization process in which the costs associated with any potential dose reduction are balanced against the benefits in a risk-informed decision-making process considering all appropriate factors. Unfortunately, current implementation of ALARA often results in a practice of dose minimization rather than a risk-informed optimization, which can lead to more harm than benefit."

The statement goes on to say, "A comprehensive review of all radiation protection regulations and practices should be undertaken by the National Research Council of the National Academies, the National Council on Radiation Protection and Measurements, or similarly qualified organization, to ensure they are consistent with the optimization approach described above and harmonized appropriately."

Just last month, the World Nuclear Association proposed a similar path in its report, *Recalibrating Risk: Putting Nuclear Risk in Context and Perspective*. In the report, the WNA calls on "policymakers and regulators to adopt an all-hazards

Letter from the CEO continues on page 26

Letter from the CEO, continued from page 25

approach, where different risks associated with energy-producing technologies are placed in perspective and the appropriate context and examined in line with the latest scientific evidence. Policymakers and regulators must ensure that their decisions regarding radiation protection do not create greater risks elsewhere. This includes the recalibration of existing regulations regarding nuclear power and radiation, weighing the cost of regulatory measures against the societal benefits provided by nuclear energy."

Finally, as you will read elsewhere in these pages, the Society, along with a coalition of other groups, has succeeded in a five-year effort to reboot the DOE's low-dose radiation research program. Now, with the help from the National Academies, the DOE will pivot away from the fruitless "not detectable vs. nonexistent" scientific debates over low-dose exposures and instead focus on balancing the risks and rewards of radiation for maximum public benefit.

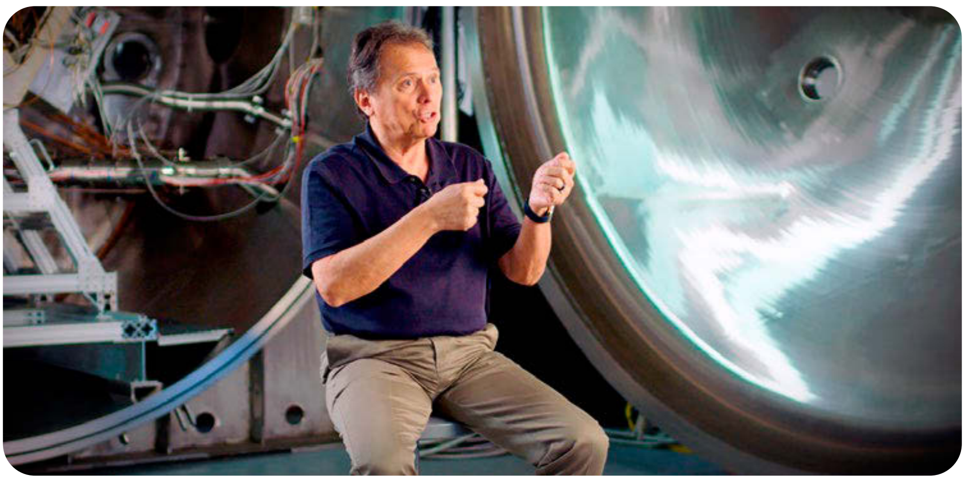
Ultimately, we may never achieve an entirely objective perception of radiation risk, but every step forward is a small victory, not only for the technology and the people who advance it, but also for humanity and planet Earth.

Virtual Field Trip, continued from page 24

Following a viewing of the video, Dunzik-Gougar was joined by several special guests, including the key participants in Nuclear Frontiers, for a brief Q&A. Panelists included Franklin Chang Díaz, NASA Hall of Fame astronaut and chief executive officer at Ad Astra Rocket Company; Candace Davison, assistant director for education and outreach in the Radiation Science and Engineering Center at Penn State University; Melinda Higgins of the U.S. Department of Energy's Office of Nuclear Energy; and David Poston, leader of the compact fission reactor design team at Los Alamos National Laboratory.

"We will still need conventional chemical rockets to get off the surface of the Earth and land on the Earth, but the interplanetary travel will be driven by nuclear power," Chang Díaz said in the video. "Space is an opportunity for the whole world, and I long to see that day when space will be a place for all." ⌧

Former NASA astronaut Franklin R. Chang Díaz talks about the ways nuclear fusion will assist in deep space travel in the "Nuclear Frontiers" virtual field trip produced by Navigating Nuclear. (Photo: Navigating Nuclear)



> “I look forward to extolling the benefits of nuclear technology while acknowledging and speaking frankly about the challenges it faces.”

STEVEN P. NESBIT: UP TO THE CHALLENGE

BY PAUL LATOUR

THE 67TH PRESIDENT OF THE AMERICAN NUCLEAR SOCIETY LOOKS TO EXPAND THE SOCIETY'S OUTREACH ACROSS THE NUCLEAR SPECTRUM.

If there's one thing Steven Nesbit enjoys in life, it's the challenge brought on by change. Whether that means growing up as a self-described "Marine brat" and moving five times before junior high school or transitioning in his professional career from the engineering side of the nuclear industry to the spent fuel and policy-driven side, Nesbit welcomes change. "I don't mind turning the crank for a while, but I like to learn new things, and the best way to do that is to do new things."

Nesbit, an expert in nuclear fuel, spent fuel, and nonproliferation, takes on his latest challenge—that of serving as the 67th president of the American Nuclear Society—eager to build on his predecessors' legacies. He sees the position as being part bureaucrat and part spokesperson for the Society. "I refer to it jokingly as 'cheerleader,' but it's actually more than that," he said. "It is representing the Society to external stakeholders and organizations, developing those relationships, and helping ANS have the role and influence that it needs to have in terms of explaining and promoting the application of nuclear technology." In many ways, Nesbit has already been fulfilling that role, having represented ANS before Congress and in the media.

An ANS member since 1989, Nesbit has held a variety of leadership positions within the Society. He is chair of the ANS Nuclear Waste Policy Task Force and past chair of the Public Policy Committee. He served as vice chair of the Special Committee on Government Relations and was a member of the Special Committee on Advanced Nuclear Reactor Policy. He chaired the Nuclear Nonproliferation Technical Group, forerunner of the Nuclear Nonproliferation Policy Division. It was in his role with the Nuclear Waste Policy Task Force that he represented ANS before Congress.

Still, as much as Nesbit enjoys a challenge, he's aware of his own limitations. He holds great respect for past president Andrew Klein (2016–2017) for introducing the Nuclear Grand Challenges initiative during his term. Nesbit said he isn't fooling himself into thinking he will top that accomplishment in his presidential tenure. "With his Grand Challenges, Andy Klein is probably the crème de la crème in terms of an ANS president leaving a memorable footprint that really resonated with the community," Nesbit said. "There's no way I'm ever going to equal that. I'm not even going to try, but I am going to have a couple of focus points as I carry out my job."

Continued

One of his objectives is to collaborate with other organizations, policy-making bodies, and individuals to improve the environment for nuclear technology, both nationally and internationally. “The presidency of ANS is, among other things, a ‘bully pulpit.’ I look forward to extolling the benefits of nuclear technology while acknowledging and speaking frankly about the challenges it faces. I think my experience on a variety of high-profile projects and my background in public policy prepares me for that role.”

Nesbit says he also wants to strengthen ties with organizations such as the Nuclear Energy Institute and the United States Nuclear Industry Council, as well as government agencies and the national labs. “There’s a whole slew of nongovernmental organizations that are interested in and supporting nuclear technology because of the potential for nuclear energy to help address the challenges of climate change, and so those are relationships that we need to continue to nurture,” he said. He sees part of his job as ANS president to be out in the public interacting with those groups, being the advocate who makes the technology accessible to those who are not immersed in the jargon and the technical details. “We have to leverage those relationships to the advantage of ANS and what we can do in terms of promoting the use of nuclear technology.”

CHILDHOOD

Born on November 28, 1958, to Charles and Patricia Nesbit on the Marine base at Quantico, Va., Steven P. Nesbit became accustomed to change from an early age. Charles was a member of the Marines, so the family moved often based on his assignments. Patricia was a stay-at-home mother until becoming a history/social studies teacher when Charles retired. In those early days, Charles, who served in the Korean and Vietnam wars, was often away on duty. But he was able to be present for Steven’s birth due to a fortunate and unexpected day off. At the time, he was a pilot in the helicopter squadron that flew President Eisenhower and Vice President Richard Nixon in Marine Corps 1. Nixon had no travel plans on the day Steven was born, so he dismissed the team for the day, which allowed Charles to be with Patricia for the birth of their second child.

Steven and his family moved five times before he was in the eighth grade. From Quantico they moved to the Greensboro, N.C., area for a year

Top left: A young Steve Nesbit holding his diploma at his Pensacola, Fla., Christian Academy graduation.

Top right: Steve and his brother, Chuck, at a beach in Pensacola.

Bottom: Steve (right) with Chuck and their father, Charles Sr.

Left: Steve (right) and Chuck heading off to school.

Right: Steve with his mother, Patricia, on his graduation day from Lejeune (N.C.) High School.

Below, top: Steve posing with his 1965 Ford Mustang at Camp Lejeune.

Below, bottom: Steve (top) enjoying time away from his studies with some University of Virginia classmates.

while Charles served in Japan. Then the Nesbits headed to Pensacola, Fla., where Charles was a flight instructor, followed by a tour of duty at the Marine Corps Air Station in New River, N.C. The family stayed near New River while Charles went to Vietnam, and that was followed by a move to northern Virginia for three years prior to returning to North Carolina, this time to Camp Lejeune, where Steve completed junior high and high school. "By and large it was a good experience," Nesbit said of his childhood. "The Marine families pull together. The downside is you move every three or four years, so you get uprooted, and you've got to make a new set of friends. But everybody else is in the same boat so you get used to it."

At the on-base Lejeune High School, Nesbit nurtured many interests, including a love of reading and playing sports. He was and still is a big reader. Although he's partial to science fiction, he was taking a crack at *Middlemarch*, the epic 19th-century novel by George Eliot, when he was interviewed for this article. Nesbit played basketball in high school but loved all sports. He said he also enjoyed all his school subjects, particularly math and science. But even that wasn't a given when it came to choosing the University of Virginia for his undergraduate work. Nesbit's older brother, Charles "Chuck" Nesbit, was already attending the school, so Steven was familiar with it. He was most impressed that it not only had a strong engineering program but also a good liberal arts college. "I figured if I didn't like engineering, I could just transfer over to liberal arts without having to go to a different university," he said.

Nesbit earned his bachelor's and master's degrees in nuclear engineering at Virginia. While there he also enrolled in the Naval Reserve Officer Training Corps, prompted by his interest in nuclear-powered submarines. That didn't last. "I decided after a couple years that I was probably not cut out for the Navy," he said. "But even though I decided not to stick with the Navy part, I figured nuclear engineering was a good way to go." By sticking with his major, Nesbit was able to gain valuable experience working with the university's research reactor. He still recalls the eerie blue glow, known as Cerenkov radiation, from the reactor core in operation. "What you typically see in pictures is spent fuel assemblies in a pool or something like that, and the glow is pretty muted," Nesbit said. "But when you're talking about a reactor core that's 19 feet away underwater and running at 2 megawatts, it's a pretty impressive sight." That experience helped solidify his career path into nuclear engineering.

CAREER

Nesbit finished his coursework at Virginia in the fall of 1981, just two years after the Three Mile Island accident, a watershed moment for the nuclear

Continued

industry. Although it might seem like a bad time to be entering the field, Nesbit said his experience was just the opposite. "One factor of Three Mile Island that people may not realize was that it was this incredible boon for the nuclear engineering job market," he said. Companies that owned or were building new nuclear plants suddenly were forced to adapt to increased regulations from the Nuclear Regulatory Commission in the wake of TMI. "Everybody was hiring—there were jobs galore," Nesbit said. "The early 1980s was a really good time for the job market, for a few years anyway."

He eventually accepted a position at Duke Energy, then called Duke Power Company, working in its safety analysis group. During the eight-plus years he spent in that department, Nesbit helped provide central office support for Duke's three reactors by doing accident simulations. He also helped write emergency operating procedures, as Duke was upgrading its simulators and striving to meet the increasingly stringent NRC regulations. While he enjoyed that work, he knew he didn't want to spend his entire career doing it. "Working for a nuclear utility, it's easy to get siloed and end up doing the same thing over and over for years and years. You become the subject matter expert on this one little aspect of the plant or technology. I didn't want to do that."

Nesbit looked around at Duke for other opportunities and ended up taking a job with Duke Engineering and Services, a subsidiary of Duke Energy. His role there allowed him to break out of the utility world and into the federal sector, which gave him a wider perspective on the industry and nuclear technology in general. "I liked being able to see other companies and other ways of doing things," he said. "That's maybe where I started to get interested in some of the policy aspects of nuclear technology. Up until that time I'd been doing primarily what I would refer to as hard engineering that really didn't get into the public policy side of things too much."

For his first job with Duke Engineering, the company was brought in by the Department of Energy as consultants for the development of a new reactor to produce tritium for nuclear weapons. But with the end of the Cold War, the need for tritium was reduced significantly, and the DOE decided to scrap the new production reactor project. That led to Nesbit's next Duke Engineering opportunity—working on the Yucca Mountain repository project.

Nesbit moved to Las Vegas in the fall of 1992 to help with the controversial project that the state of Nevada was vehemently opposed to. Frustration with the project eventually led Nesbit to seek another position with Duke back in Charlotte. "I got to work with a lot of really smart and dedicated people on the Yucca Mountain Project in fields I probably never would have interacted with if I'd have stayed as just a utility guy," Nesbit said. "I got an understanding and appreciation of a part of nuclear technology, the

Top: Steve with William States Lee III, the former chief executive officer of Duke Power Company, while working on the Yucca Mountain Project in Las Vegas, Nev.

Bottom: Steve providing testimony during the Senate Energy and Natural Resources Committee hearing on nuclear waste management on June 27, 2019, in Washington, D.C.

Steve standing at the summit of Mount Charleston, the highest point in Clark County, Nev., in 2013.

waste management end of things, that I hadn't been exposed to. The day-to-day work experience may not have been the most pleasant, but I probably learned as much or more in those three years out at Yucca Mountain as I have in any other three years I've had in my professional career."

Nesbit transferred back to Charlotte in 1995 to work on other Duke Engineering high-level waste projects, which included a generic design of an interim storage facility for spent nuclear fuel. A year later, Nesbit started work on a Duke Energy initiative to convert weapons-grade plutonium into mixed oxide (MOX) fuel that can be used to power reactors. Just like with Yucca Mountain, the project was controversial and further exposed Nesbit to policymakers in Washington, D.C. "This project was technically challenging but also involved public relations, stakeholder interactions, the policy issues, all that kind of stuff. So it was really a watershed thing for me to work on," he said.

Nesbit became the manager of the Duke Energy portion of the project, which involved preparing nuclear power reactors to use MOX fuel and obtaining the necessary approvals from the NRC. After nine years on the project and the successful loading and use of MOX fuel lead test assemblies at the Catawba Unit 1 reactor, Nesbit again switched roles, becoming the spent fuel manager at Duke.

More change was on the way. Within a year, Nesbit felt an itch to return to technical work, so he took off his manager hat and joined Duke's methodology group for the next several years. In 2009, he accepted a position as director of nuclear policy and support for Duke, reporting to the company's chief nuclear officer. He stayed in that role until he retired in 2018, handling a variety of assignments, including serving as the company's spokesperson on the Fukushima accident. But the bulk of his policy work involved spent fuel in some capacity. He worked closely with the Electric Power Research Institute and other groups to examine and evaluate spent fuel storage solutions.

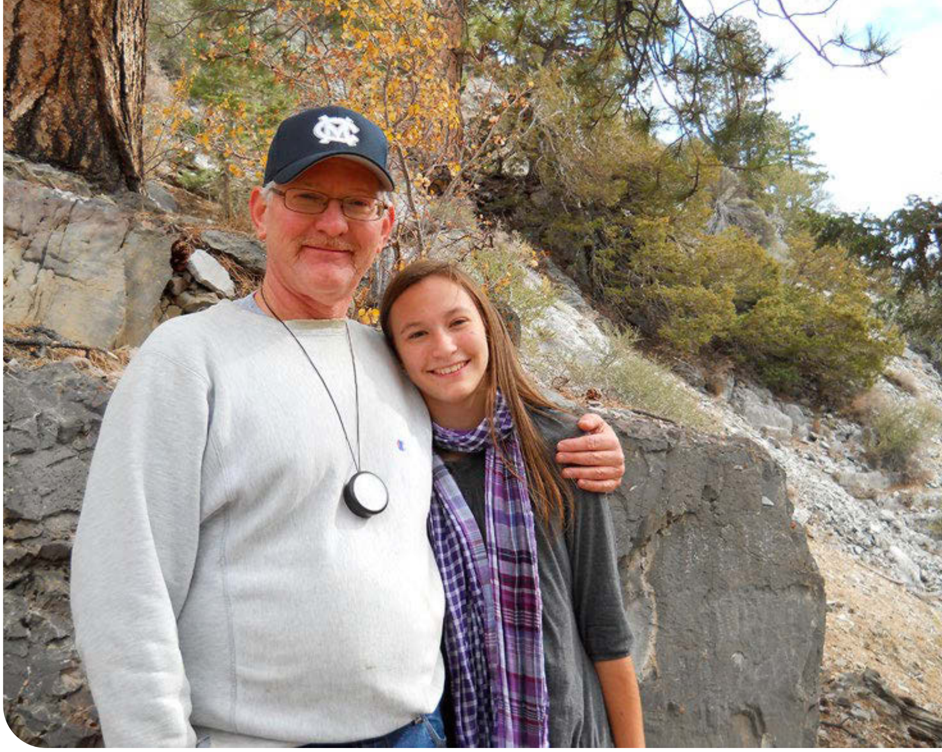
"The technical consensus now is that there's no reason why we can't store spent fuel for a very long time in the dry storage containers that they were originally loaded into," Nesbit said. "We don't know how much longer, but it's a lot longer than the original license period of 20 years. And we've developed a means of monitoring the spent fuel canisters while they're in storage to make sure that they maintain their integrity, which is very important as well."

Nesbit also represented Duke with various industry groups. He testified before the House Energy and Commerce Committee's Subcommittee on the

Continued

Top: Steve with his oldest daughter, Rachel, outside of Las Vegas during a 2011 hike.

Bottom: Steve with his three children—Rachel, Benjamin, and Rebecca—during a hiking trip to Grand Teton National Park in 2014.



Environment on April 26, 2017, on behalf of the U.S. Nuclear Industry Council and Duke, and before the Senate Energy and Natural Resources Committee on June 27, 2019, on behalf of ANS. Both appearances were related to waste management issues.

When Nesbit parted ways with Duke, he wasn't ready to retire altogether. So he decided to go the consulting route and created LMNT Consulting in 2019. "I've been fortunate enough since then to have plenty of work to do in a variety of areas," Nesbit said. "I'm glad I went into consulting instead of taking a full-time position with another company. I get to work from home and do fun and interesting things and get paid for it."

FAMILY LIFE

Nesbit and his first wife, Jeanne, married in 1993 and had three children together, Rachel, Benjamin, and Rebecca. The couple divorced in 2011. Aside from his work and professional interests, Nesbit stayed busy with his children's activities when they were young, doing some coaching, taking them on mission trips with their church, and supporting their school projects and extracurricular activities. In 2009, he started and taught a course on nuclear engineering for fourth-year mechanical engineering students at the University of North Carolina at Charlotte. "I taught it for four years and really got a lot out of it," he said. "I'm glad I did it, and I'm glad UNCC gave me the chance to." For recreation, Nesbit likes to spend time outdoors, including skiing in the winter and hiking year-round.

Nesbit and his current wife, Shelley, married in the mountains near Asheville, N.C., on June 28, 2019—just a day after his second appearance before Congress. It made for a hectic couple of days, but Nesbit pulled it off. "I managed to do the testimony and then a little ANS webinar and still catch the flight back to Charlotte in time to run up to the mountains and get married that weekend," he said.

It was just another example of Nesbit's ability to succeed in meeting a challenge.

Paul LaTour is a staff writer for Nuclear News.


POWER
PLUG INTO NET ZERO
NUCLEAR @
IDAHO NATIONAL LABORATORY

RaFTS:

The Radiation Field Training Simulator

Training for the **realities** of radiological incidents and emergencies

By Greg White,
Steve Kreek,
William Dunlop,
Joshua Oakgrove,
Dan Bower,
Dave Trombino,
Erik Swanberg,
and Steven Pike

One of the biggest challenges in training for incidents and emergencies that involve high-radiation-dose hazards is balancing between **realism** and **safety**. To be truly prepared for the realities of real-world nuclear and radiological emergencies, responder personnel need experience against those hazards but without introducing additional and very personal risks associated with unnecessary radiation exposure. The difficulty is in figuring out how we can achieve a level of realism that encompasses the entire process, from the initial detection of a hazard or threat, through its characterization, to recommending actions and leadership decision-making.

Facing page: Dave Trombino searches for a simulated plutonium source. The detector output is being controlled by the prototype RaFTS device. (Photo: LLNL)

Continued

To ensure the highest level of preparedness, responder personnel ideally need to train against robust, real-life scenarios that occur in locations relevant to them and that enable them to utilize their own operational equipment. All too frequently, the vast array of health and safety, regulatory, and logistical challenges of hands-on radiological training using truly hazardous radiation sources can make this desired level of realism impractical or impossible.

In many cases, a simpler course of action would be for an event controller to spoon-feed radiological information to their trainees during an exercise—perhaps by communicating what their instruments should be reading or by using simulator detectors that have been preprogrammed to respond in a specific way. It's common for controllers to say, "Here's what your detection instrument would have said, had a real hazard been present," during an exercise.

The perennial problem with this approach is that real-world radiological instruments (spectrometers in particular) can often behave very differently when operating in high-hazard environments and against large or distributed radiation sources. Additionally, responders experience differences psychologically when facing an actual, invisible radiation hazard versus an artificial hazard. What is vital is that responder personnel can experience these differences for themselves, but without the risks associated with using real, hazard-level radiation sources. Nevertheless, we must ensure that they are not surprised by those differences during a real-world emergency.

Instructors who wish to conduct training using actual radiation detection equipment typically have two main choices: either to use some form of small, nonhazardous radiation point source or to employ virtual simulation, albeit based upon a digital representation of the equipment.

Both of these approaches face the common problem of satisfactorily approximating the physical complexities of a live, large-scale nuclear event with any sufficient degree of realism. For example, if using a small radiation source, it ideally needs to be placed either directly on top of or sufficiently close to the detector to elicit a response. A source becomes increasingly harder to observe at increasing distances—even if the source is set just a foot or two farther away. At larger distances, the hazard can become virtually undetectable.

Using small sources to represent large-scale contamination or hazard-level sources can also be problematic, with the physics of radiation detection being easily diluted, misinterpreted, or missed altogether. If conducting contamination exercises, small, contained radiation sources are not always able to replicate a distributed contamination zone, which can cause confusion for the operator, particularly because radiation detectors can behave as if the radiation is coming from all directions (which it is).

In the case of search exercises, the use of live sources can often result in trainees following the lead of the yellow-vested safety technician whenever their instruments are not reading anything.

When using live sources for training, the regulatory administration and whole-life-cycle economic impact of these live sources are also significant factors.

Virtual reality offers the benefit of being able to approximate how an instrument might "read" radioactivity. However, the use of virtual reality can also risk oversimplifying the true operational realities of emergency response. When training virtually, trainees also miss the ability to experience the crucial physical and physiological factors of hands-on training—whether it is the heaviness of their equipment, their screen becoming unreadable in the sunlight, or their device being too large for them to crawl through a tight space.

Greg White displays data being generated by a vehicle-transportable radiation detector controlled by RaFTS. (Photo: LLNL)

The Radiation Field Training Simulator

In a bid to address some of these shortcomings in radiological training, Lawrence Livermore National Laboratory, together with British simulator detector manufacturer Argon Electronics Ltd., has devised the Radiation Field Training Simulator (RaFTS).

RaFTS combines virtual hazard and real-world detection capabilities to enable responder personnel to experience highly realistic radiological training that recreates all the practicalities of operating against a live radiation hazard—and for them to be able do so while using their own operational detector equipment. In contrast to simulator detectors, which duplicate the look and feel of real detectors, RaFTS technology produces a response within the actual radiation detectors in use and replicates all the physics of real-world usage. RaFTS bridges the gap between simulation and how the personnel's actual equipment responds to realistic hazards, capturing the psychological aspect as workers see their instruments respond in real time and in ways that replicate the expected physics.

The technology also allows radiological exercises to be delivered in any location, from a parking lot to a downtown area (to simulate fallout, for example) or within a public building using discrete simulation sources.

Continued

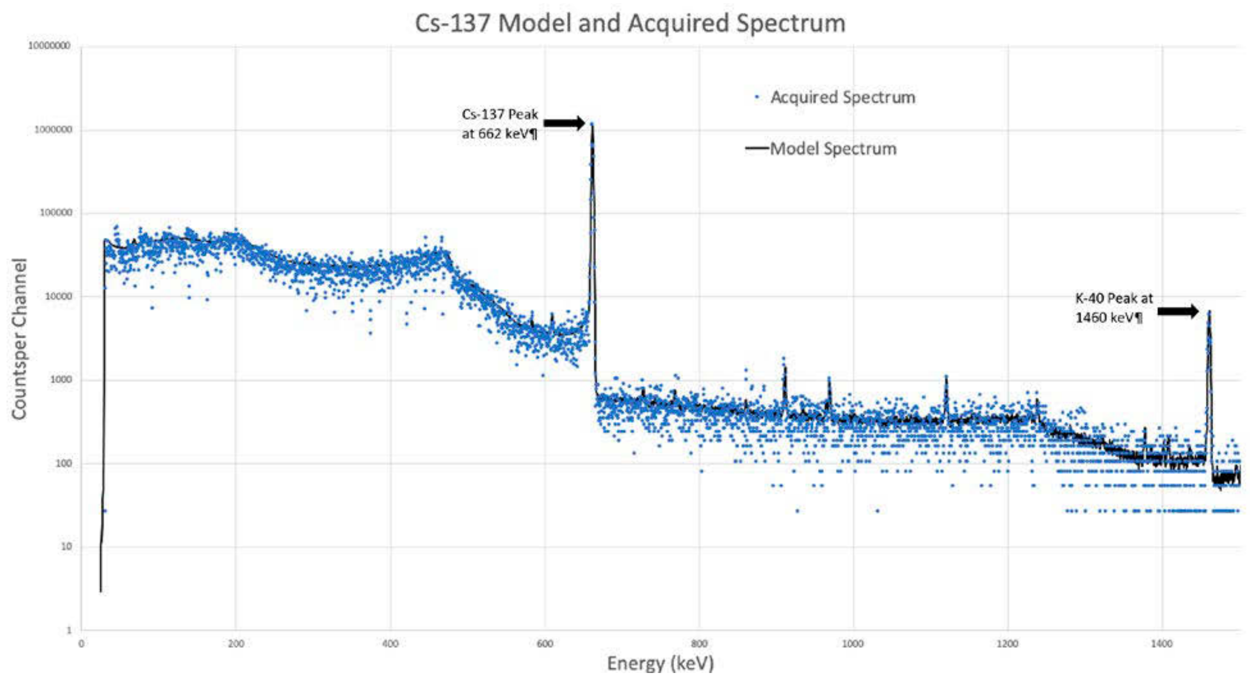
RaFTS capabilities

RaFTS provides radiological instructors with the ability to inject simulated data into the actual radiation detection instruments that responder personnel will use when responding to real-life radiological incidents. A precalculated scenario can be easily programmed into RaFTS, with the option to include multiple radiation sources, which can be either dispersed or in fixed locations.

The technology draws upon detailed scenarios based on actual U.S. national emergency response capabilities, such as those of the National Atmospheric Release Advisory Center. More sophisticated scenarios can be created with the direct support of LLNL.

The data generated for these sophisticated scenarios are prepared as inject signals that feed directly into the trainees' suitably adapted operational detectors, enabling them to practice both response and their reachback protocols with the highly realistic data collected by their instruments. The data injection occurs and is controlled by the physics of the operator's encounter with the hazard and how they are using their instrument, which significantly increases the realism of the training exercise—for example, reducing the need for exercise controllers.

RaFTS is able to generate signals that make the operational detector respond as if radiation sources are present, and it works with detection instrumentation that spans the range of capability that is commonly in use. Some detectors simply provide a measurement of the radiation dose (a simple rate), while others are capable of sorting the various energies that are present and are used to identify and characterize the source in detail. The generated signals are injected into detector systems in place of, or in addition to, the signals naturally present in background or other radiation sources that may be present, such as commercial products or even signals from persons that recently received medical treatments like stress tests or thyroid irradiation.



More sophisticated response instruments are able to separate radiation by the energies present needed to identify the radiation source(s). This graph shows a comparison of two sets of data: an actual cesium-137 radiation energy spectrum, combined with natural background (potassium-40 and radon-228), which is used as the model (black line) baseline; and the RaFTS-generated spectrum (blue dots). The RaFTS energy spectrum started as simulated preamplifier pulses, which went through a shaping amplifier and into the instrument energy sorting hardware (a multichannel analyzer). The energies of the detected peaks were then used to identify the radioactive isotopes that are present. Note that the Cs-137 peak is at 661 keV (the first large peak) and the background peaks are those such as K-40 at 1460 keV. The shapes of each peak (denoted as the full-width at half-maximum) are the same. The RaFTS spectrum was scaled to match the model spectrum counts.

While the primary concept has been to inject signals into a port provided on an adapted detector, it will also be possible to implement a dedicated simulator by means of sensor substitution. This provides maximum flexibility to the user community to be able to upgrade their existing equipment or procure capable instruments during recapitalization.

RaFTS outputs are of sufficient quality to ensure that the detection instruments respond exactly as they do to actual radioactivity. The data collected provide a sufficient degree of realism to enable the identification of the radioactive species present, its characterization, and the localization of a radioactive source.

A significant benefit provided by the integration of RaFTS is the extreme high quality of the output energy spectra, which can be processed and sent to reachback centers just like in real life. Therefore, reachback expertise and advice or recommendations can be incorporated into the exercise. The fidelity of the information contained in the "energy spectrum" is based on the type of detector, the source of the radiation, and the physics of how the user encounters the source and uses their instrument. The system allows any radioactive material or materials to be represented in the scenario. The strength of the signal will depend on the size of the source, the distance to the detector, and how long the operator uses their instrument. It can also be modified to allow for intervening shielding materials, just as would occur in reality.

The relationship between Argon and LLNL also provides RaFTS with compatibility with a wide variety of Argon's existing radiological training systems.

Trombino (right) demonstrates the RaFTS device with a high-purity germanium detector. (Photo: LLNL)

Testing, demonstration, and optimization

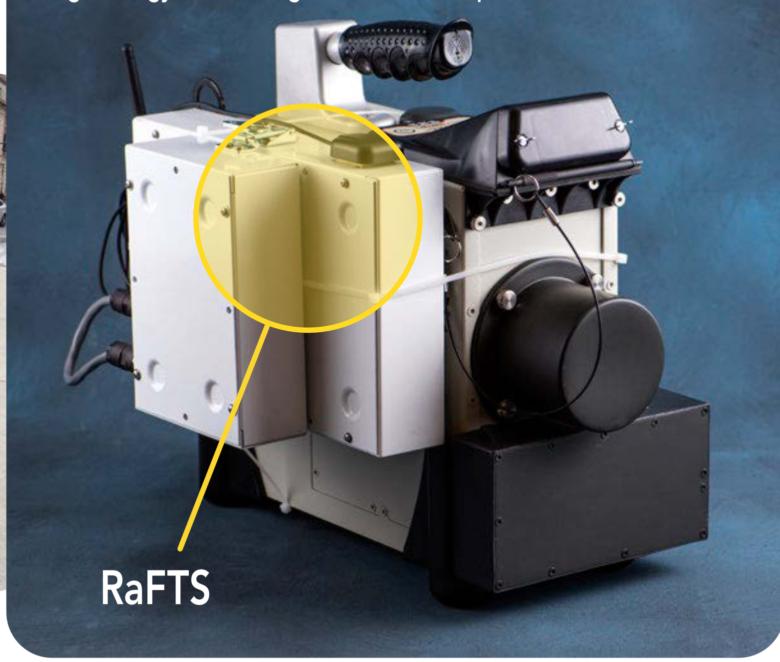
RaFTS was first publicly demonstrated in Washington, D.C., in 2016 using the operational semiconductor-based detector the Ortec Detective X high-purity germanium radioisotope identification device. The HPGe-based detector provides the highest ability to separate gamma rays of different energies, useful for identifying and characterizing the sources.

RaFTS has also been successfully integrated with a commonly available detector based on sodium iodide. The NaI-based detector is less capable of separating the energies but is more commonly available—for example, in devices such as the TerraTracker adaptable radiation area monitor (ARAM)–enabled mobile SUV, used by the Department of Homeland Security and local authorities in the New York/New Jersey region.

The integration with ARAM demonstrates the ability to incorporate RaFTS into mobile as well as handheld detectors. Body-worn "backpacks," fixed-site detectors, and portal monitors are also suitable candidates for integration.

The developers of RaFTS are confident that the same technology will work on a variety of instrument types through a common interface, which will yield a universally adaptable simulation tool that can be used to train against a broad array of radiological sources and scenarios.

RaFTS is shown attached to the exterior of a commercial high-energy-resolution gamma radiation spectrometer. (Photo: LLNL)



Continued

RaFTS is connected to a commercial handheld low-energy-resolution gamma radiation spectrometer (based on NaI). GPS hardware is used for location, and a tablet displays the collected spectral data. (Photo: LLNL)

To date, the technology has also been viewed by the Department of Energy, various components of the Department of Homeland Security, the State Department, and the Defense Threat Reduction Agency, as well as international organizations such as the International Atomic Energy Agency and the Comprehensive Nuclear-Test-Ban Treaty Organization.

Technical development of RaFTS

Work is now underway to reduce the size and weight of RaFTS to make it easily portable (the size of a typical pager is the objective). The current RaFTS equipment has been tested in extreme environments, down to temperatures well below freezing. As the design is miniaturized, continual quality tests will be conducted to ensure performance is maintained across a broad range of environmental conditions including cold, high humidity, and other outdoors environments.

The RaFTS hardware and software are also being enhanced to handle more complex scenarios—for example, to allow for instances where a source is moving (e.g., within a vehicle) or where the scenario is changing over time due to radioactive decay, weather conditions, etc. (e.g., a plume release). LLNL is also leveraging its scenario generation capabilities to support Argon's wide-area instrumented training system PlumeSIM, which will enable the staging of even more involved scenarios.

The developers of RaFTS have worked in close collaboration with the manufacturers of radioactive measurement devices to gain the required access to their signal chain and continue to welcome additional detector manufacturer partners. In the shorter term, LLNL and Argon are developing a standard RaFTS interface that can be retrofitted with existing detectors to enable them to accept RaFTS inputs. Longer term, the goal is to coordinate with detector manufacturers in the standardization of their next-generation detection equipment so such devices could come pre-equipped with a RaFTS injection port.

The future of radiological training

Steven Pike (left) and Philip Dunn (middle) of Argon Electronics Ltd., which has licensed the RaFTS system, are being shown its operation by Dave Trombino (right). (Photo: LLNL)

To be truly prepared for the challenges and the complexities of real-world emergencies involving high-radiation-dose or high-threat hazards, it is vital that responder personnel can practice using their actual equipment in those environments. The effectiveness of current radiological training methods can often be constrained by safety considerations—that is, the difficulties of creating realistic scenarios and yielding realistic configurations using (for safety reasons) only small-quantity, hard-to-detect radiation sources.

With the development of RaFTS, there is now the opportunity for responder personnel to develop vital familiarity with their actual equipment, and to do so while operating against highly realistic and scientifically sound scenarios that replicate the conditions they will encounter in real life.

G. White, S. Kreek, W. Dunlop, J. Oakgrove, D. Bower, D. Trombino, and E. Swanberg are with Lawrence Livermore National Laboratory in the United States, and S. Pike is with Argon Electronics Ltd. in the United Kingdom. This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344, Lawrence Livermore National Security LLC.

China's electron for treating indust

With the capacity to treat 30,000 cubic meters of wastewater per day, the largest industrial wastewater treatment facility using electron beam technology in the world was inaugurated in China in June 2020. The treatment process has the capacity to save 4.5 million m^3 of fresh water annually—equivalent to the amount of water consumed by about 100,000 people.

Operating at the world's largest producer of knitted fabric and dyed yarn, the Guanhua Knitting Factory in southern China, the treatment plant uses electron beam technology to treat water polluted with industrial dye residues, whose molecules are too unwieldy to be broken down using bacteria or chemicals. These long and complex molecules are decomposed by a stream of high-energy electrons generated by accelerators, resulting in water that can be reused.

BEAM TECHNOLOGY
RIAL WASTEWATER

BY CARLEY WILLIS AND JOANNE LIOU

Photo: Institute of Nuclear and New Energy Technology

The textile industry consumes huge amounts of water and chemicals, such as dyes, starches, acids, salts, and detergents, which are discharged during the production process. “Normally, such wastewater would be treated with chemical processes, which generate secondary waste,” said BumSoo Han, a radiation chemist at the International Atomic Energy Agency. “Electron beam treatment is an eco-friendly and cost-effective method of wastewater treatment, as it saves the treatment time and cost for chemical solutions, and no secondary waste is generated.”

The textile industry in China, the world’s largest producer, has used chemicals to treat wastewater. But with strengthened policies on environmental protection, the industry is turning to nuclear technology and electron beams, which offer a highly efficient wastewater treatment method.

Continued

The treatment plant at the Guanhua Knitting Factory in southern China uses electron beam technology to treat water polluted with industrial dye residues. The residues' molecules are too unwieldy to be broken down using bacteria or chemicals.

(Photo: Institute of Nuclear and New Energy Technology)

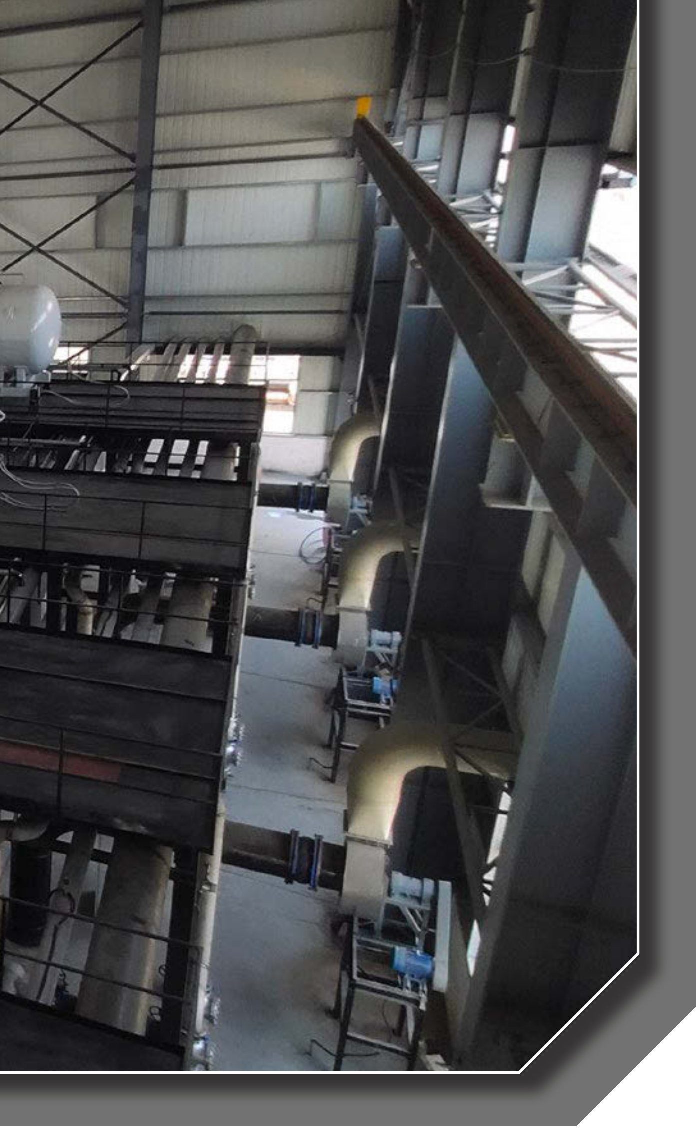
SEEDS OF DEVELOPMENT

It all started as an IAEA project in 2012, through which Chinese scientists developed a program to treat wastewater with electron beams. The IAEA's support included fellowships at existing laboratory facilities using electron beam technology in other countries, a training course, and advice from visiting experts, who provided guidance on project development.

In 2017, a pilot facility in Jinhua City, 300 kilometers southwest of Shanghai, was built with the capacity to treat 1,500 m^3 of wastewater per day from a nearby textile factory. Two years after the launch of this demonstration project, construction of a commercial treatment plant at the Guanhua Knitting Factory began. Constructed by CGN Nuclear Technology Development Company (CGNNT), a subsidiary of China General Nuclear Power Corporation, the new wastewater plant treats more than 30,000 m^3 of wastewater per day through the operation of seven electron accelerators.

"Over 70 percent of the wastewater that runs through this operation can be reused in the factory, up from the previous reuse rate of 50 percent," said Dongming Hu, general manager at CGNNT. "This means less water directly from the nearby river is needed for the operation of the factory, saving 4.5 million m^3 of water every year."

Given the growing emphasis on ecological practices, innovative solutions are key for environmental protection, while simultaneously supporting industrial development. "This project is a notable example of how a small amount of seed support from the IAEA contributes to stimulating the emergence of sustainable industrial practices in a country," said Gashaw Wolde, who manages the IAEA's technical cooperation projects in China. "The result is cleaner, more efficient industrial processes that clearly have a socioeconomic impact at national scale."



The success of this project has been widely shared with other industries in China to implement the technology to treat increasing amounts of wastewater due to industrial and agricultural development and population growth. “We have a high amount of wastewater discharged in China, and it is difficult to treat it with conventional technologies,” said Shijun He, a professor at the Institute of Nuclear and New Energy Technology at Tsinghua University. “But with electron beams, we can greatly improve the discharge water recycling rate.” Other demonstration projects are underway in Xinjiang, Hubei, and Guangxi Provinces. “We are working on implementing electron beam technology in a variety of industries, such as the pharmaceutical industry, in China,” He added.

HOW IT WORKS

Because of the various types of wastewater generated by different industries, there is no universal treatment process. Conventional water treatment technologies include filtration and chemical and biological treatments. Nuclear-derived techniques, based on advanced oxidation-reduction processes such as electron beam and gamma radiation involving free radicals, have emerged as promising solutions to combat micropollutants.

The main goal of radiation processing—the use of ionizing radiation to modify or synthesize materials—is to convert nonbiodegradable pollutants into simpler molecules that are more susceptible to biodegradation. “Radiation techniques using electron beam technology can decompose the large amounts of contaminants in the wastewater and remove these complex pollutants,” the IAEA’s Han said.

In radiation processing, an accelerator generates an electron beam that ionizes water molecules. The absorbed energy disturbs the electron system of the water molecules and results in the breakage of interatomic bonds. Highly reactive products from the radiolysis of water molecules react with the harmful organic contaminants. An advantage of the electron beam technology is that the reactive components are generated in situ, during the radiolysis process, without the addition of any chemicals.

Hydrogen peroxide and the hydroxyl and hydroperoxyl radicals are oxidizing species, while hydrogen atoms and hydrated electrons are chemical reducing in nature. “The simultaneous existence of strong oxidants and strong reductants within wastewater under treatment is both remarkable and one of the important characteristics of radiation processing,” Han said. “The hydroxyl radical, by virtue of the high radiation–chemical yield of the formation, as well as its high oxidation potential, is the most predominant species. The oxidation power of the hydroxyl radical is much higher than that of conventional industrial oxidants, such as chlorine, hypochlorous acid, or potassium dichromate.”

The degradation of pollutants occurs in less than a second, a faster rate than conventional processes, which can take days. “These products’ reactions with impurities in water typically require less than 1 microsecond to break down or convert contaminants,” Han explained. The contaminants then degrade and become simpler chemical forms, making the wastewater easier to treat through traditional methods.

Continued

A cutaway illustration of Brazil's mobile electron beam unit.
Source: Nuclear and Energy Research Institute

THE PAST AND FUTURE OF WASTEWATER TREATMENT

The first studies on the radiation treatment of wastes, principally for disinfection, were carried out in the 1950s. In the 1960s, these studies were extended to the purification of water and wastewater. By the 1990s, several pilot plants, including mobile electron beam facilities, were deployed for studies, and since then, the IAEA has coordinated a range of research projects related to irradiation treatment of contaminated waters and sludges and the remediation of polluted waters and wastewater by radiation processing.

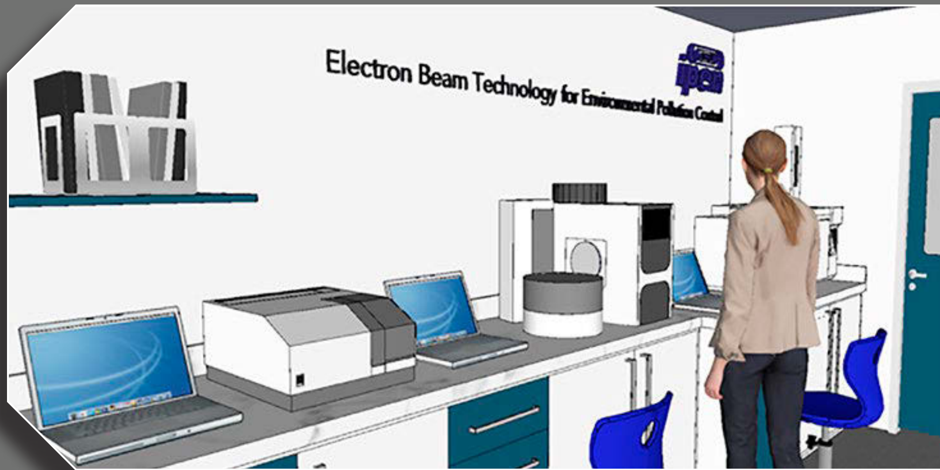
Wastewater treatment using radiation has not yet found wide application, as it tends to be costlier than using chemicals. However, pilot plants and industrial-scale studies, from the Americas to Europe and Asia, have shown that radiation processing could have a bigger impact in the future as stricter environmental rules curb the use of chemicals.

With the support of the IAEA, in 2005, South Korea established the first industrial plant for the treatment of textile dye wastewater using an electron beam, with the capacity to treat 10,000 m^3 of wastewater per day. In a recent project in Brazil, the Nuclear Energy Research Institute of the National Nuclear Energy Commission, in cooperation with the IAEA, constructed a mobile electron beam unit to enhance national capacity to treat industrial effluents from chemical, pharmaceutical, and petroleum production for reuse. The mobile unit treats up to 1,000 m^3 of effluents per day on-site, providing an effective way to demonstrate the efficacy of the electron beam technology.

In 2019, the IAEA launched an international research project to further develop and demonstrate radiation technologies to treat emerging organic pollutants (EOPs) in wastewater. "Though low levels of emerging contaminants, such as endocrine-disrupting compounds, antibiotics in water, and polyfluorinated compounds in soils, may not cause an immediate lethal effect, they could have chronic effects on human and animal health and the ecosystem in general," Han said. The four-year project brings together

Brazil's Nuclear and Energy Research Institute of the National Nuclear Energy Commission, in cooperation with the IAEA, constructed a mobile electron beam unit. The mobile unit treats up to 1,000 m^3 of effluents per day on-site, enhancing Brazil's capacity to treat industrial effluents from chemical, pharmaceutical, and petroleum production for reuse.

(Source: Nuclear and Energy Research Institute)



An artist's conception of some of the interior of the mobile lab.

The tractor trailer that houses the mobile electon beam unit.

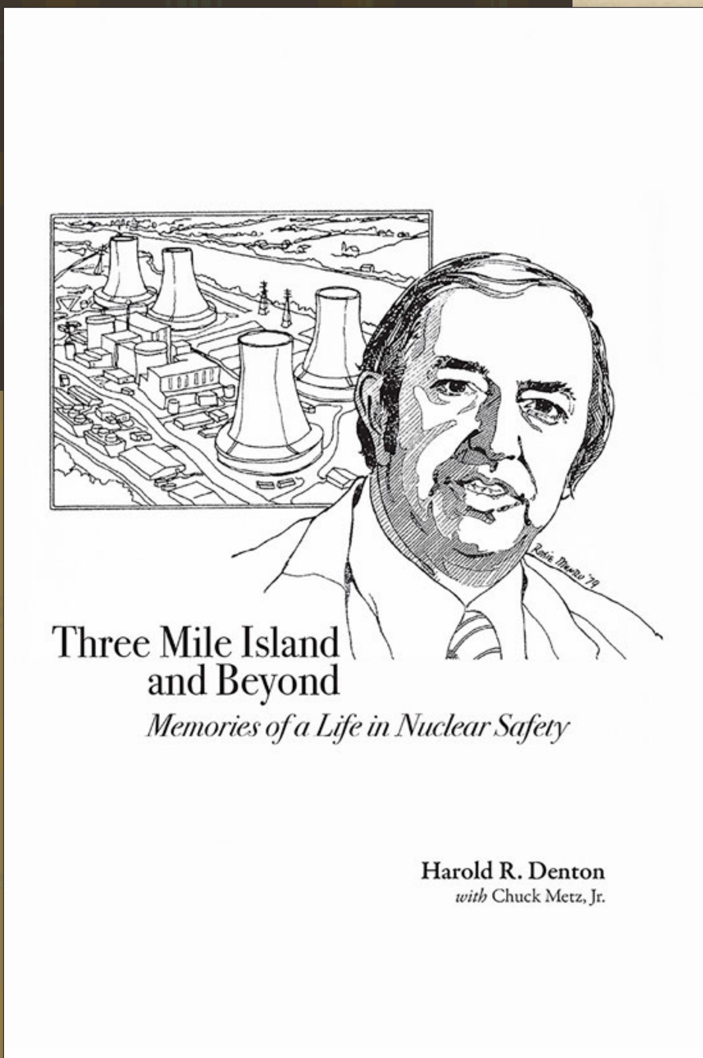
experts from Argentina, Bangladesh, Brazil, China, Egypt, Hungary, Malaysia, Myanmar, Poland, Serbia, Slovakia, Tunisia, Turkey, the United States, and Vietnam.

In addition to the research objectives, experts involved in the project are developing standard operating procedures for treating EOPs with different radiation treatment technologies and are establishing toxicity measurement assays to determine if the degradation of EOPs by radiation leads to the formation of toxic byproducts. "There is a need to harness radiation technologies to address the environmental pollution caused by EOPs," Han explained. "A multidisciplinary approach that includes the development of new analytical methods to detect pollutants and a deeper understanding of pollutant degradation mechanisms is needed."

Carley Willis and Joanne Liou are with the International Atomic Energy Agency's Office of Public Information and Communication.

Metz on Harold Denton:

Pictured above: Chuck Metz Jr.



Memories of a life in nuclear safety

Chuck Metz Jr. discusses his collaboration with Harold Denton, whose memoir interweaves a retelling of the Three Mile Island accident events with stories of his career-long advocacy for nuclear safety.

A number of years ago, historian and writer Chuck Metz Jr. was at the Bush's Visitor Center in Tennessee's Great Smoky Mountains when he ran into former Nuclear Regulatory Commission official Harold Denton and his wife. Metz was at the visitor center, which opened in 2010 and is now a tourist hotspot, because, as he explained to the Dentons at the time, he had overseen the development of its on-site museum and had written a companion coffee-table history book.

The chance meeting turned into a friendship and a fruitful collaboration. Denton, who in 1979 was the public spokesperson for the NRC as the Three Mile Island-2 accident unfolded, had been working on his memoir, but he was stuck. He asked Metz for help with the organization and compilation of his notes. "I was about to retire," Metz said, "but I thought that exploring the nuclear world might be an interesting change of pace."

Denton passed away in 2017, but by then Metz had spent many hours with his fast friend and was able to complete the memoir, *Three Mile Island and Beyond: Memories of a Life in Nuclear Safety*, which was published recently by ANS. Metz shared some of his thoughts about Denton and the book with *Nuclear News*. The interview was conducted by *NN*'s David Strutz.

The TMI accident has been widely researched and written about over the years. What makes this book different? What was the motivation behind writing it?

The book is different, of course, because it is the first to relate the perspective of one of the key players involved in resolving the accident. Harold oversaw the NRC's response to the accident and its subsequent cleanup efforts. As the director of the NRC's Office of Nuclear Reactor Regulation, he had the technical expertise to oversee the accident's resolution. His role as President Jimmy Carter's personal representative provided him the platform to relay those efforts to a national audience. Harold became the face that Americans saw on their televisions, and his open and reassuring manner played a significant role in allaying fears regarding TMI.

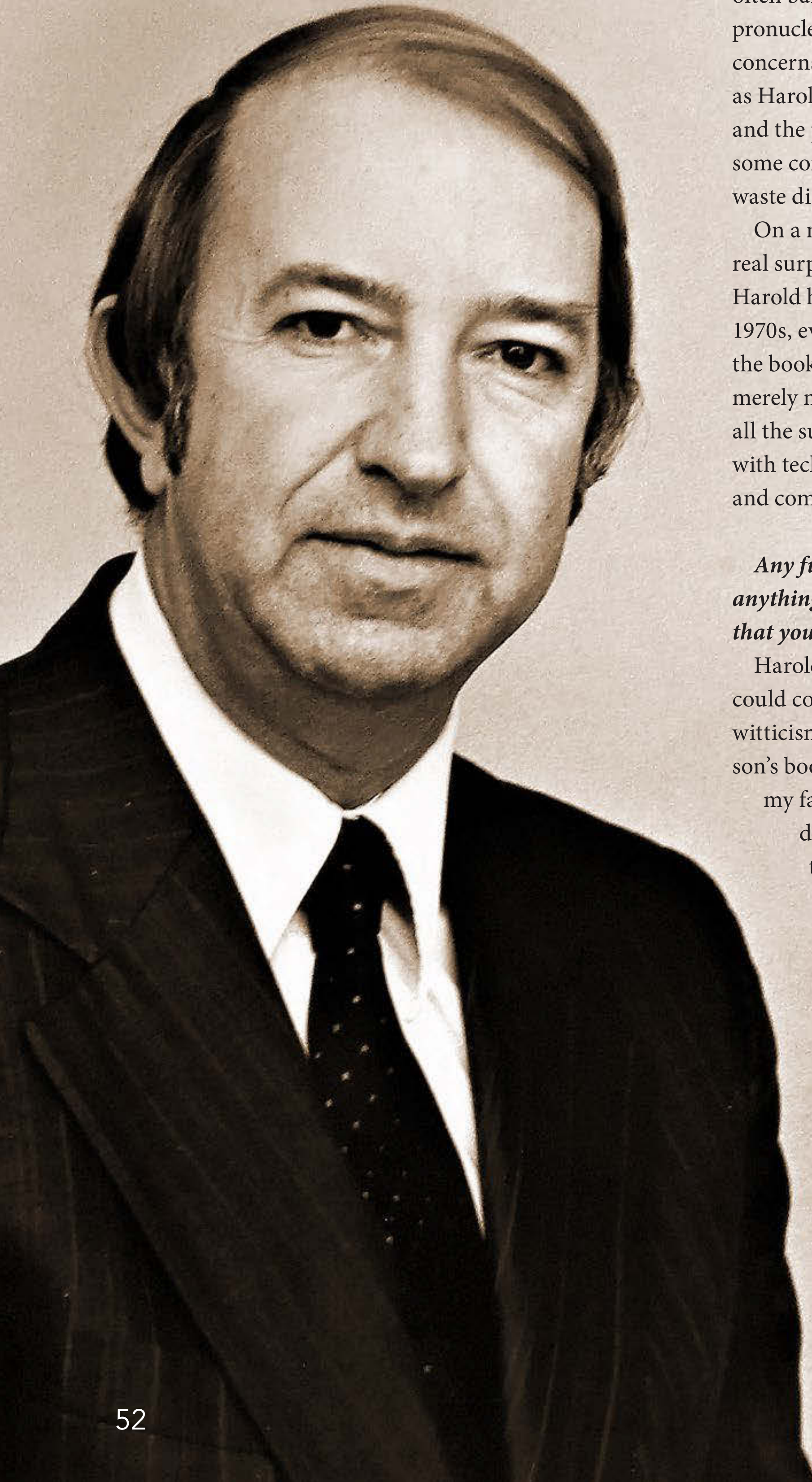
How would you describe this book? It seems to be part history, part memoir.

If I had to define one thing about Harold, it's that he was passionate about nuclear safety. He was adamant that if the United States was going to use nuclear energy, then the technology would be kept safe on his watch. That passion drove his career before, during, and after TMI. Since, as he said many times, his name will always be linked with the TMI accident, the book had to provide the relevant history around it. But excellent histories, such as Sam Walker's *Three Mile Island: A Nuclear Crisis in Historical Perspective*, already exist, and so there was no need to recapitulate that work. As I looked at a book framework to both tell the TMI story and relate Harold's larger safety message, I decided it worked best to weave alternating history chapters from his perspective with correlating portions of his safety message.

Who would you suggest read this book? Is it suitable for nonnuclear folks?

Harold spoke, of course, to his peers in the nuclear industry and was very involved in his profession. The book should certainly appeal to nuclear industry professionals. But Harold also had a passion, and a gift, for explaining the technical to nonnuclear audiences. This was evident during the TMI accident when he spoke to fearful television audiences on a national scale. And it carried over during the decades after the accident when he spoke extensively to audiences around the world.

Continued



What is the most surprising thing you learned researching this book?

I suppose it is the breadth of the nuclear energy industry and the many details involved in its operation. That's a rather broad answer, but like most laypeople, I think, I knew virtually nothing about the field. But because I'm science-focused, "trusting the science," as is so often bandied about these days, it is easy for me. I lean pronuclear, but only because the science is sound. Any concerns I might have would revolve around the people, as Harold so eloquently states—operators, human error, and the possibility of laxity and corner cutting. I also have some concerns around our inability to fully resolve the waste disposal issues.

On a more granular note, one thing I learned that was a real surprise to me is that there are floating nuclear plants. Harold had to deal with FNP technology back in the mid-1970s, even testifying about them in Congress. As said in the book, FNP technology "never really went away but has merely moved forward in time, and now we must deal with all the surrounding complexities." I find that need to deal with technology and safety across generations important and compelling.

Any funny anecdotes working with Harold? Did anything (funny or not) not make it into the book that you or Harold wished could have?

Harold had a wonderfully wry sense of humor. He could come across with some of the driest and wryest witticisms. His story around owning Fidel Castro's son's books, found in a store in Nevada, was one of my favorites. [Castro's son Fidel Junior held a doctorate in nuclear physics and was head of the Cuban nuclear regulatory agency.] But my favorite memory perhaps is a mental image rather than an anecdote. Harold would come to my house in the early days before he became ill, and he would sit in a rocking chair in my living room to relate his stories. We don't keep our house really cool, but Harold was always cold, so he would wrap himself up in a blue "Snuggie" I had. That image is both humorous and a very fond memory.

Left: Denton, around the time of the TMI accident.

Next page: Denton in 2014 at a gathering marking the 35th anniversary of the TMI accident.

Harold of course knew President Carter because of the TMI accident, and the president had some training in nuclear physics. Did Harold relate to you any stories about his interactions with Carter?

Harold had a good relationship with the president. He said, "I was fortunate reporting to President Carter and Governor Thornburgh, and I can't think of anyone else I would rather have had on this accident management team." He enjoyed that Carter could readily understand the physics issues around TMI and that he wasn't above making suggestions.

I found the stories around Carter's trip to visit the TMI site during the accident most interesting. Harold worried about the president's impressions during that trip—that the site hadn't been cleaned up enough and that the president might lose some confidence. And of course, the infamous radiation dosimeter incident, where the president and first lady had been given dosimeters that already had been used and thus showed some exposure. They hadn't really taken any radiation, which was a relief to all. Harold found that mistake so embarrassing.

And as said in the book, Harold was both surprised and humbled at the trust and free rein that Carter gave him to manage the accident. Harold was always amazed that he had the ability to get whatever he needed done without a lot of red tape.

TMI-1 closed just last year, and TMI-2 has recently been transferred to new ownership for final decommissioning. What do you think Harold would think about that? And about the wider state of the nuclear power industry right now?

He would not be surprised. As he came to the end of his career, Harold often wondered if the nuclear energy option would survive. Economics, public opinion, politics—there were so many challenges facing it. He discusses them throughout the memoir. At times he would become a little pessimistic about the industry's future, but I believe he hoped it would endure.

What is the biggest takeaway or lesson discussed in the book?

Nuclear energy is neither good nor bad in a moral sense. It is science, and as such, can be utilized if sound technologies are developed and good operative procedures are followed. Harold always considered himself neither for nor against the nuclear energy option. But he always insisted that if a nation was determined it was going to use nuclear energy, then that use had to be as safe as humanly possible. He spent his career advocating for nuclear safety. This book goes into extensive detail regarding his nuclear safety reflections and is as highly relevant to the nuclear discussion today as during TMI, Chernobyl, or Fukushima.

What was the biggest challenge in writing the book?

I was one of those nonnuclear folks that Harold was so passionate about reaching. Although my own layperson's passion revolves around science in all fields, it took a great deal of learning to become familiar with the esoteric nuclear energy field. But I had faced a similar, though less arcane, situation when I wrote my history of Bush Brothers & Company. I learned more than I ever would have thought about beans! The same goes for nuclear. That's what makes writing so attractive, this learning about widely varying subjects.

Is there anything I didn't ask that is interesting or important that readers should know about?

Harold truly was as humble as he was so widely perceived to be, a true "man without guile," as I've said. His reflections around the many subjects he touches upon throughout his book are as relevant to the nuclear energy discussion today as they were during his career. He was both technically competent and a passionate advocate about nuclear safety, and it is telling that even antinuclear advocates respected and easily talked with him.

A hot cell at Argonne National Laboratory was used to demonstrate a process for purifying molybdenum-99, an important diagnostic medical isotope. (Photo: Wes Agresta/ANL)

A critical shift in low-dose radiation research and communication

By Susan Gallier

The biggest impact of radiation in our lives may come not from radiation itself, but from regulations and guidelines intended to control exposures to man-made sources that represent a small fraction of the natural radiation around us.

Decades of research have been unable to discern clear health impacts from low levels of ionizing radiation, leading to calls for a new research program—one with a strategic research agenda focused on how the scientific understanding of the health effects of low doses (below 100 millisievert) and low dose rates (less than 5 mSv per hour) can best be augmented, applied, and communicated.

The American Nuclear Society has supported just such a study since a low-dose radiation research program within the Department of Energy's Office of Science was defunded and later terminated in 2016. In response to input from ANS and other stakeholders, Congress reauthorized DOE low-dose radiation research in the bipartisan Energy Act of 2020, and a new coordinated federal low-dose radiation research program is now underway. The program will be guided by a strategic plan developed by a committee of the National Academies of Sciences, Engineering, and Medicine and will integrate and expand on the research of past decades without treading the same well-worn path.

Continued

A new direction

Ourania "Rania" Kosti is a senior program officer at the National Academies' Nuclear and Radiation Studies Board with an educational and research background in biochemistry and molecular medicine. As the study director for the new committee, she is responsible for assembling a balanced group of experts and helping them issue a report.

Kosti

According to Kosti, the benefits of the new program could be tremendous. "That's because low-dose radiation is everywhere, and it affects a lot of different decisions and disciplines in life," she said. "If you get the program right and you start understanding more about these very complicated questions about risks at low doses, you could start making more informed decisions about applications in medicine, emergency preparedness, waste management, and more."

The committee of about 10 individuals will include experts on radiation biology, radiation epidemiology, and radiation protection, as well as social sciences, communication, education, and program management.

A prescriptive approach is not part of the plan. "Instead, the committee will discuss the main questions that the program needs to try to address and current gaps in knowledge," Kosti said. "Then the Department of Energy hopefully will take that advice and make decisions about the exact topics that they need to fund." The committee may also make recommendations about how various federal agencies can coordinate their work with universities and international partners. Information about the Committee on Developing a Long-Term Strategy for Low-Dose Radiation Research in the United States, including opportunities for public comment, will be added to the committee's web page as it becomes available. Visit nationalacademies.org and search for the committee by name.

Patterns of the past

Central to current radiation protection regulations is the linear no-threshold (LNT) model, which assumes that radiation harm increases linearly with exposure and that zero harm exists only at zero exposure. The LNT model may result in overestimates of risk from low levels of radiation, and resources expended to meet LNT-based standards may yield little or no benefit. In fact, fear engendered by those standards, and well-intentioned protective actions—such as the evacuation of elderly and hospitalized people from the area surrounding the Fukushima Daiichi plant—may cause unintended harm to members of the public.

People are exposed to many cancer risk factors, including stress, genetics, pollution, and occupational hazards, and the difficulty of isolating the effects of specific risk factors can complicate research on low-dose radiation health effects. Some rigorous attempts to ascertain whether low doses of ionizing radiation can increase the risk of cancer have necessarily been inconclusive. Decision makers have repeatedly deferred decisions to replace the LNT model and instead have called for more research.

Piercy

"This is an issue that has been around as long as nuclear technology," said Craig Piercy, ANS executive director and chief executive officer. "There remains a fundamental lack of understanding of the health impacts at very low doses, so the scientific questions end up focusing on whether a particular impact is nonexistent or just too low to detect. A better question—the one being asked now—is, how do we apply what we already understand about radiation to drive better decision-making?"

The new research program could potentially lead to the adoption of new standards and new ways to communicate about low-dose and very-low-dose (below 10 mSv) radiation, even if the LNT model is not replaced. The strategic plan developed by the National Academies specifically calls for the program to "support education and outreach activities to disseminate information and promote public understanding of low-dose radiation" and to "identify and, to the extent possible, quantify potential monetary and health-related impacts to federal agencies, the general public, industry, research communities, and other users of information produced by such research programs."

ANS grand challenge

Paul Dickman, a senior policy fellow at Argonne National Laboratory, has served for several years on the ANS Public Policy Committee and on the National Academies' Nuclear and Radiation Studies Board. He has been at the center of ANS's efforts to revitalize the DOE's low-dose research program.

Dickman

"The issue of low-dose radiation has always been a grand challenge for ANS [ans.org/challenges/radiation/] because we recognize that the current regulatory regimes are not risk informed," Dickman said, adding that overly conservative regulations are the result.

"Radiation is natural," Dickman said. "Humans evolved in a radioactive environment, and we are exposed to radiation every day. But radiation has become a thing of fear as opposed to being accepted as something natural."

A risk-informed approach to low-dose radiation would acknowledge that Americans receive a radiation dose of about 6.2 mSv each year (about half from natural background radiation and half from man-made sources).

"We regulate the amount of radiation you can get from drinking water but not from flying or going to the dentist," Dickman said. "Our regulations are inconsistent, not harmonized, and often not based on modern science. We need to understand how the low-dose science really applies and translate that into public health standards that make sense."

A catalyst for change

Dickman and Kosti agree that the Gilbert W. Beebe Symposium on the Future of Low-Dose Radiation Research in the United States, convened in May 2019, marked a turning point for low-dose radiation research.

"A lot of members of the radiation protection and research community were saying that it needs to be a decision-driven process," Kosti said. "In other words, you don't do research for the sake of research, but you do it because you try to ask, understand, and answer important questions about risks at low doses."

Government representatives participated in a panel discussion during the 2019 Gilbert W. Beebe Symposium on the Future of Low-Dose Radiation Research in the United States. Standing at the lectern is Jim Brink, of Harvard Medical School, who moderated the discussion. (Photo: NAS)

Continued

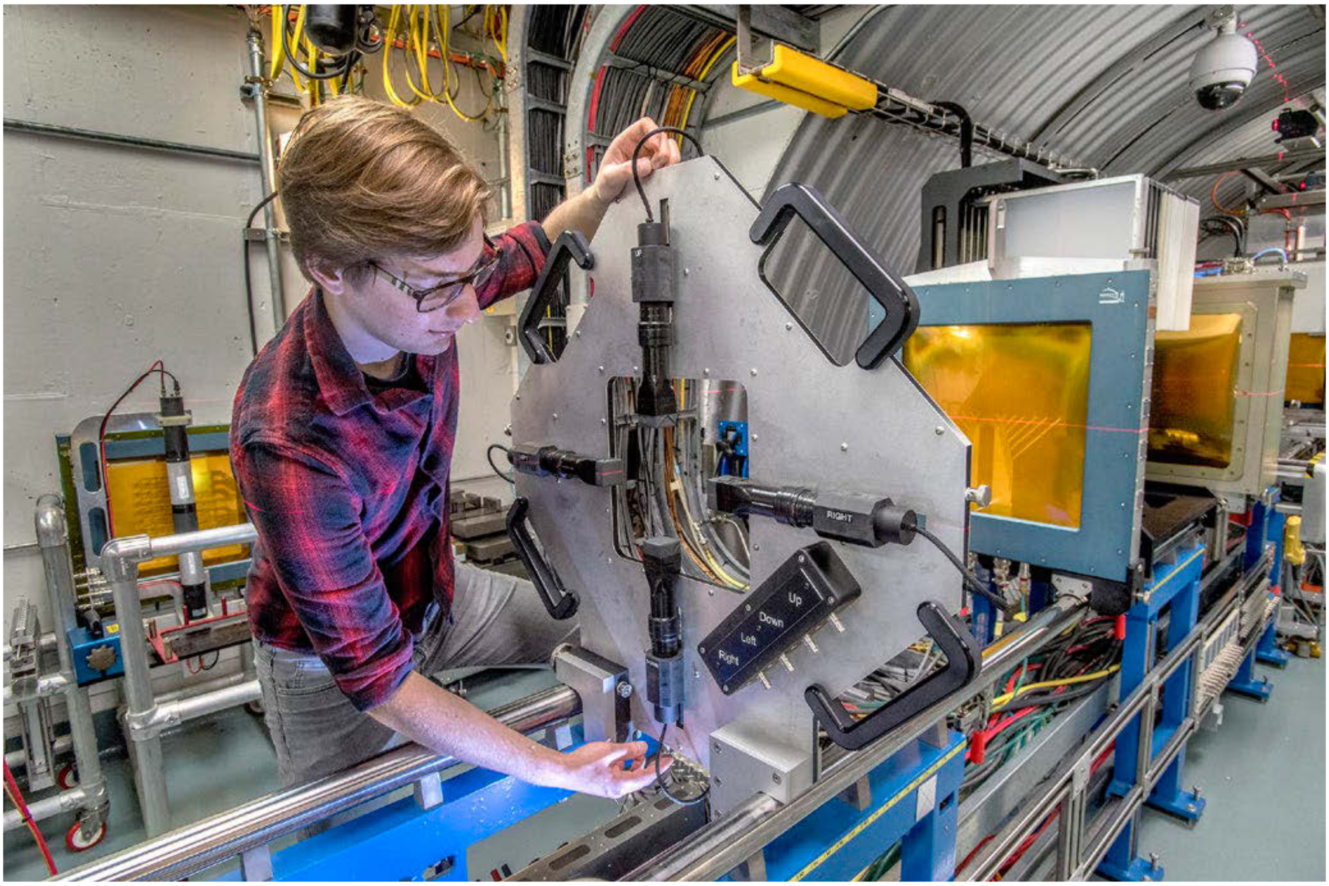
Dickman described the symposium as "the catalyst" that led ANS to organize a consortium with the Health Physics Society, the Clean Air Task Force, and Oak Ridge Associated Universities. That consortium worked with congressional and DOE staff to encourage the involvement of the National Academies in establishing a strategic research agenda. In July 2020, it participated in a National Academies' webinar to emphasize the need for research that has a direct impact on radiation protection policy.

"As a Society, our goal has been the establishment of a scientific basis for modern low-dose radiation regulation," Dickman said. "The NAS study is an important step in achieving that goal. But these programs don't happen overnight, and we need to stay engaged."

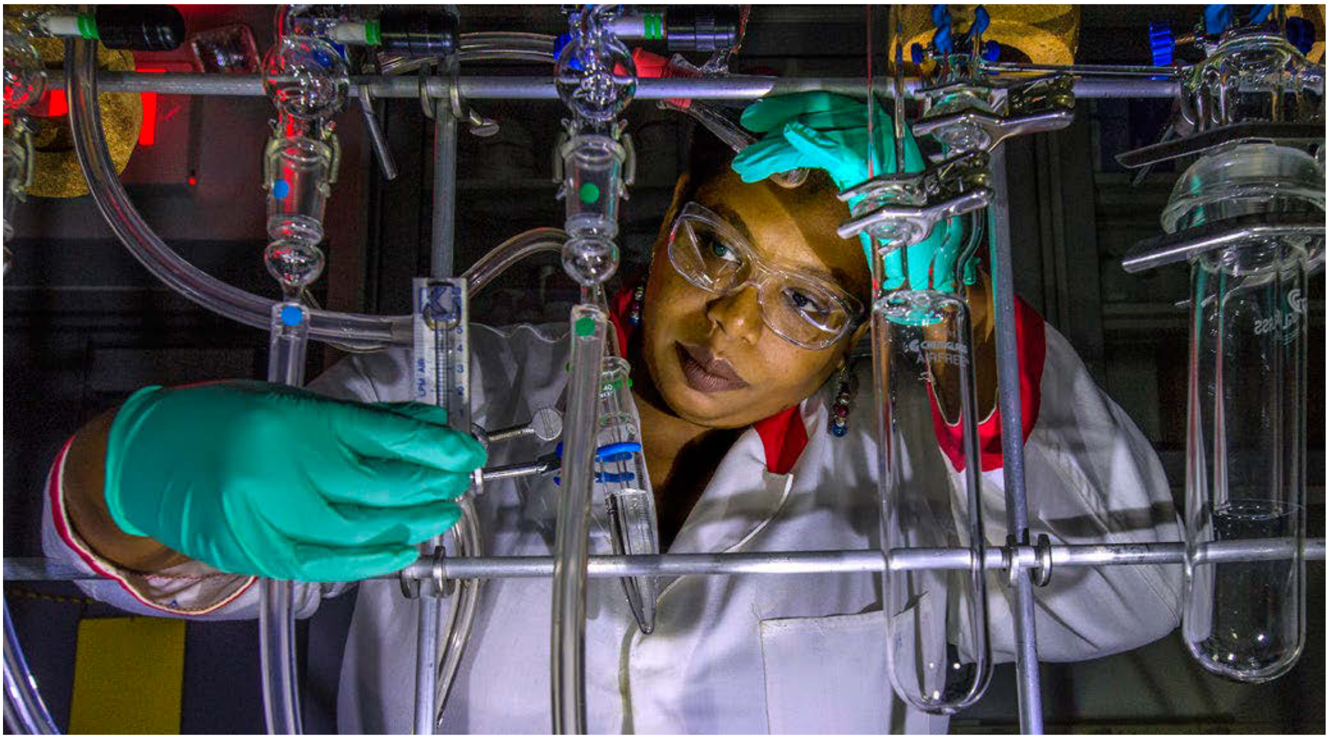
Potential applications

If new research leads to the conclusion that there is effectively a threshold below which no harm occurs, nuclear utilities and waste management programs could expend resources in a more balanced, risk-informed way, potentially saving billions of dollars and improving safety. Revised radiation protection guidelines could incorporate lessons learned from the response to the Fukushima Daiichi accident and ensure that actions undertaken in the name of public safety do not cause more harm than they prevent.

The ramifications of a coordinated federal low-dose research program would extend beyond the purview of the DOE, the Environmental Protection Agency, and the Nuclear Regulatory Commission. For example, NASA seeks to understand the impacts of radiation on astronauts for future missions, while the Department of Transportation and the Federal Aviation Administration have the authority to regulate doses received by transportation workers. Federal health agencies, including the



The NASA space radiation laboratory at Brookhaven National Laboratory. (Photo: BNL)



Doctoral student Jasmine Hatcher works in Brookhaven National Laboratory's Medical Isotope Research and Production Program in 2018. (Photo: BNL)

National Institutes of Health and the Centers for Disease Control and Prevention, have a key role in communicating about the health effects and benefits of radiation.

"Everybody is talking about personalized medicine," Kosti said. "If we understand more about individual susceptibility to low-dose radiation, this could be part of the decision-making process for a medical professional. The committee will be raising the health and safety issues that need to be guided by an improved understanding of low doses, and age, sex, genetic factors, and others will be part of the health and safety questions that we need to address."

A new BEIR report?

The primary mission of the National Academies' committee is to make recommendations to the DOE's Office of Science and add structure to the new low-dose research program. "One of those recommendations may say we need to develop a statement of work for a BEIR VIII report," Dickman said. The Biological Effects of Ionizing Radiation (BEIR) VII report, *Health Risks from Exposure to Low Levels of Ionizing Radiation*, released in 2006 by the National Academies' National Research Council, essentially upheld the LNT model.

"There's a fair amount of unanimity among the key research scientists in this field that we should be looking at how to incorporate studies done over the past 15 to 20 years into a new BEIR VIII," Dickman said. "But from an ANS perspective, we believe that we need to also consider how BEIR VIII can support harmonizing regulations and communication. This NAS study should help define future efforts."

Kosti expects the committee to hold its first meeting this summer and to issue a report in March or April 2022. "We're going to need input from absolutely every stakeholder out there," she said. "And it's not just the research and federal radiation protection community, but members of the public and anyone who cares about low-dose radiation. And that's pretty much everyone."

Susan Gallier is a Nuclear News *staff writer focusing on nuclear technology research and applications.*

Support for nuclear energy grows with climate change concerns

By Ann S. Bisconti

Public discourse on energy and climate increasingly includes nuclear energy, but how has that affected public opinion? The answer: a lot. A national public opinion survey conducted in May found that support for nuclear energy has rebounded, and politics, in part, may offer a window into why. For example, now Biden and Trump voters support nuclear energy about equally. Trump voters care more about affordable and reliable electricity. Biden voters care more about climate change, and their support is driven by perception of need. Perception of need is boosted by climate change, recent energy supply problems, and Democratic leadership endorsements. The importance of Democratic leadership endorsements is shown in the Obama bump in 2010 and the Biden bump in 2021. In both cases, the increase in overall support for nuclear is largely attributable to increased support among Democrats.

The survey, with 1,000 nationally representative U.S. adults, has a margin of error of plus or minus 3 percentage points and was conducted by Bisconti Research Inc. with Quest Global Research Mindshare Online Panel. The report includes trend data going back 38 years.

Support for nuclear energy

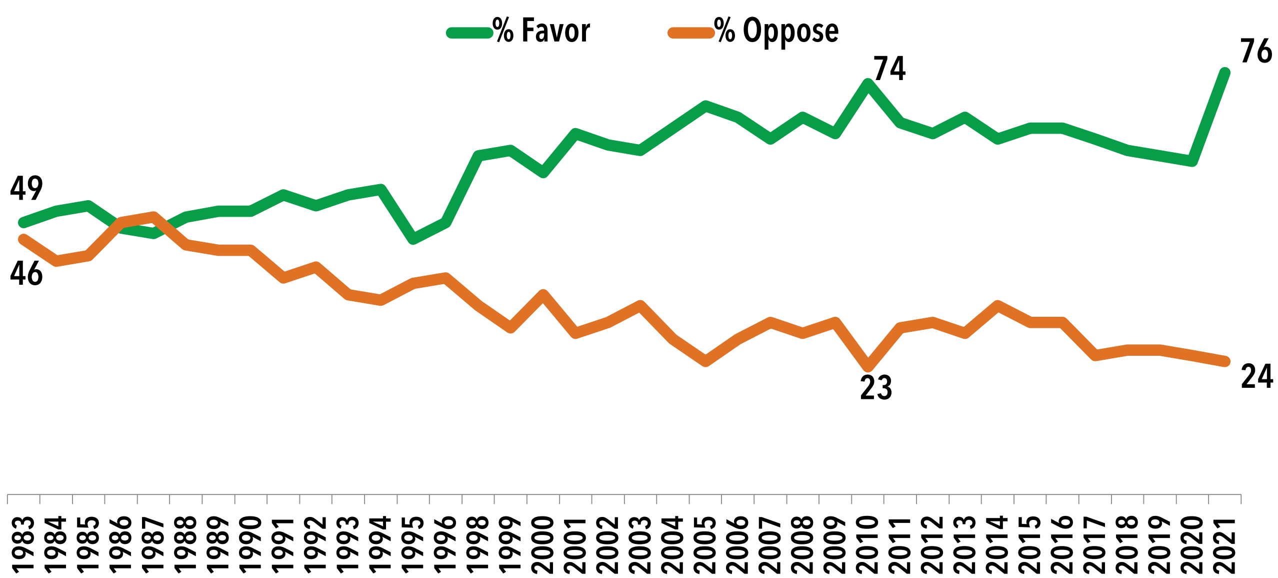
Overall, 76 percent of respondents said they strongly favored or somewhat favored the use of nuclear energy as one of the ways to provide electricity in the United States; 24 percent are opposed. The previous peak in favor of nuclear was in 2010, when 74 percent favored nuclear energy and 23 percent opposed it. In the interim, favorability had plateaued in the 60 percent range. Now, 32 percent strongly favor nuclear energy, and 6 percent are strongly opposed.

Most Americans (83 percent) believe that nuclear energy will be important in meeting the nation's electricity needs in the years ahead. The survey also found support for license renewal and new plants: 86 percent agreed that we should renew the licenses of nuclear power plants that continue to meet federal safety standards, 85 percent agreed that our nation should prepare now so that advanced-design nuclear power plants will be available to provide electricity, and 69 percent agreed we should definitely build more nuclear power plants in the future.

Continued

Favorability to Nuclear Energy 1983–2021

Overall, do you strongly favor, somewhat favor, somewhat oppose, or strongly oppose the use of nuclear energy as one of the ways to provide electricity in the United States?



Perception challenges

Findings show improvements regarding two perception challenges: perception of nuclear power plant safety and perception of public opinion. For the first time since the 2011 earthquake off the coast of Fukushima, Japan, and resultant tsunami and nuclear accident, perceptions of nuclear power plant safety have made a significant upturn. Compared with 2020, high safety ratings increased from 47 percent to 57 percent, and low safety ratings decreased from 23 percent to 19 percent. Perceptions of safety of nuclear power plants historically have been influenced by perceptions of need for nuclear energy.

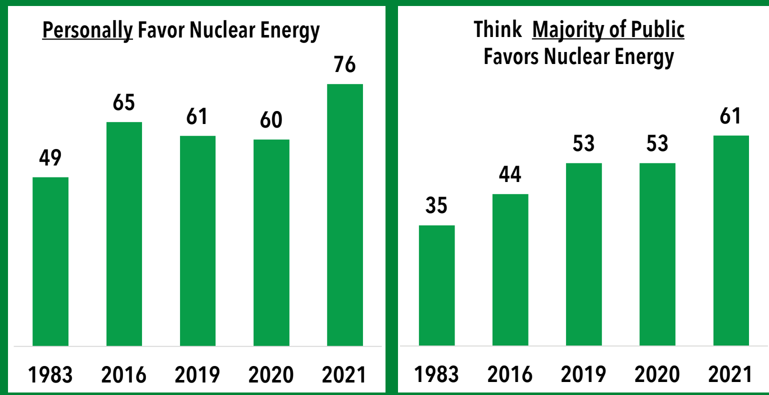
Also, perceptions of public opinion historically have been much less favorable than actual public opinion. That perception gap points to an image challenge. Surveys from 2019 to 2021 have found that the perception gap is changing. There is still a wide difference between individuals' support and their perceptions of others' opinions on nuclear energy. However, for the past three years, a majority of people say that they believe that the majority of the public favors nuclear energy.

Vanishing Perception Gap?

Perception of Public Opinion More Favorable Now

Overall, do you strongly favor, somewhat favor, somewhat oppose, or strongly oppose the use of nuclear energy as one of the ways to provide electricity in the United States? (%)

Do you think that the majority of people in your community favor or oppose the use of nuclear energy? (%)



Communications insights

Public opinion on nuclear energy is highly changeable. Most members of the public have never held a strong opinion for or against nuclear energy. In the May poll, 32 percent strongly favored nuclear energy and 6 percent strongly opposed it. The remaining 62 percent can be considered fence-sitters. More women than men are fence-sitters: In the May poll, just 21 percent of women strongly favored nuclear energy and 8 percent are strongly opposed. Among men, 45 percent strongly favored nuclear energy and 2 percent are strongly opposed.

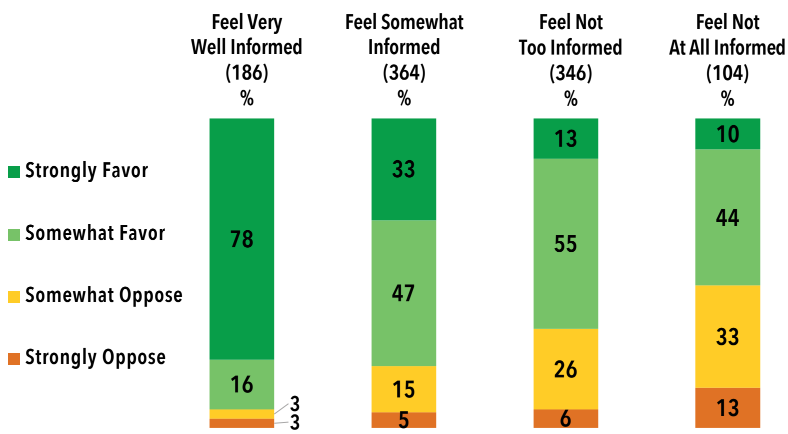
Few people feel very well informed about the topic. In this poll, only 19 percent felt very well informed, including 27 percent of men and 12 percent of women. Also notable is the large generational difference, with Millennials feeling best informed about the subject. Fewer than 10 percent of the two older generations, Silent and Boomers, said they feel very well informed, compared with 16 percent of Gen Xers, 31 percent of Millennials, and 21 percent of Gen Z.

The more informed people feel about nuclear energy, the more they favor it. In 2021, of those who felt very well informed about nuclear energy, 78 percent strongly favored it—and only 3 percent strongly opposed it. If feeling very well informed is a likely prerequisite to activism, one can understand why antinuclear activism has come from a very small group of people. The small segment of the population that feels very well informed and strongly opposed to nuclear energy exerts an outsize influence on perceptions of public opinion.

The More Informed People Feel, the More Favorable

*How well informed do you feel about **nuclear energy used to produce electricity?** (Number in parentheses is the number of respondents.)*

Overall, do you strongly favor, somewhat favor, somewhat oppose, or strongly oppose the use of nuclear energy as one of the ways to provide electricity in the United States?



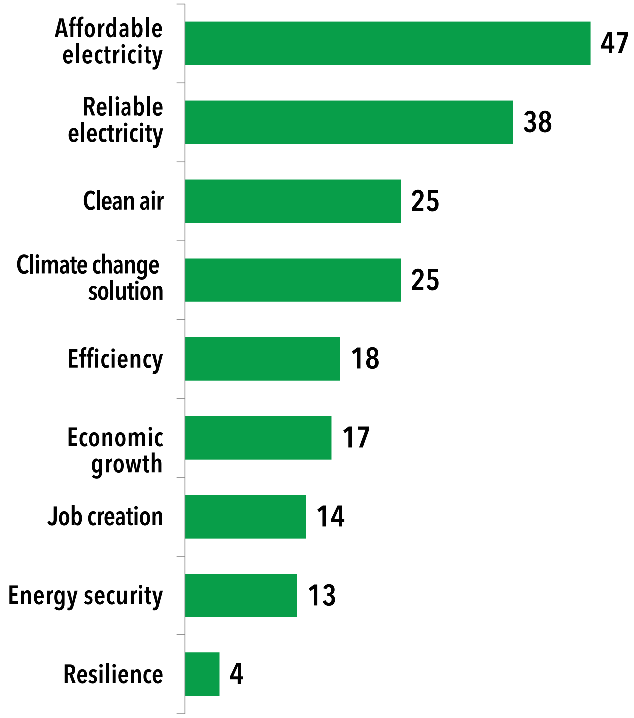
For communications, it is wise to focus on what the public values most. In this survey, respondents were asked about the importance to them of 9 considerations for the way electricity is produced. They were *not* told that these considerations are all benefits of nuclear energy. First, they rated the considerations. All were rated extremely important or very important. Second, they selected the two considerations that are most important to them. As in previous surveys, the top three considerations are affordable electricity, reliable electricity, and clean air. In this survey, the climate change solution consideration tied with clean air when respondents picked the two most important considerations. These considerations surpassed efficiency, economic growth, job creation, energy security, and resilience.

For information on nuclear energy, the public trusts experts in the field. Most credible are a safety engineer at an area nuclear power plant, a scientist at a U.S. government national laboratory who is developing advanced-technology nuclear energy, the U.S. Nuclear Regulatory Commission, and a university professor of nuclear science. Least credible are an antinuclear organization, Congress, and the news media.

Continued

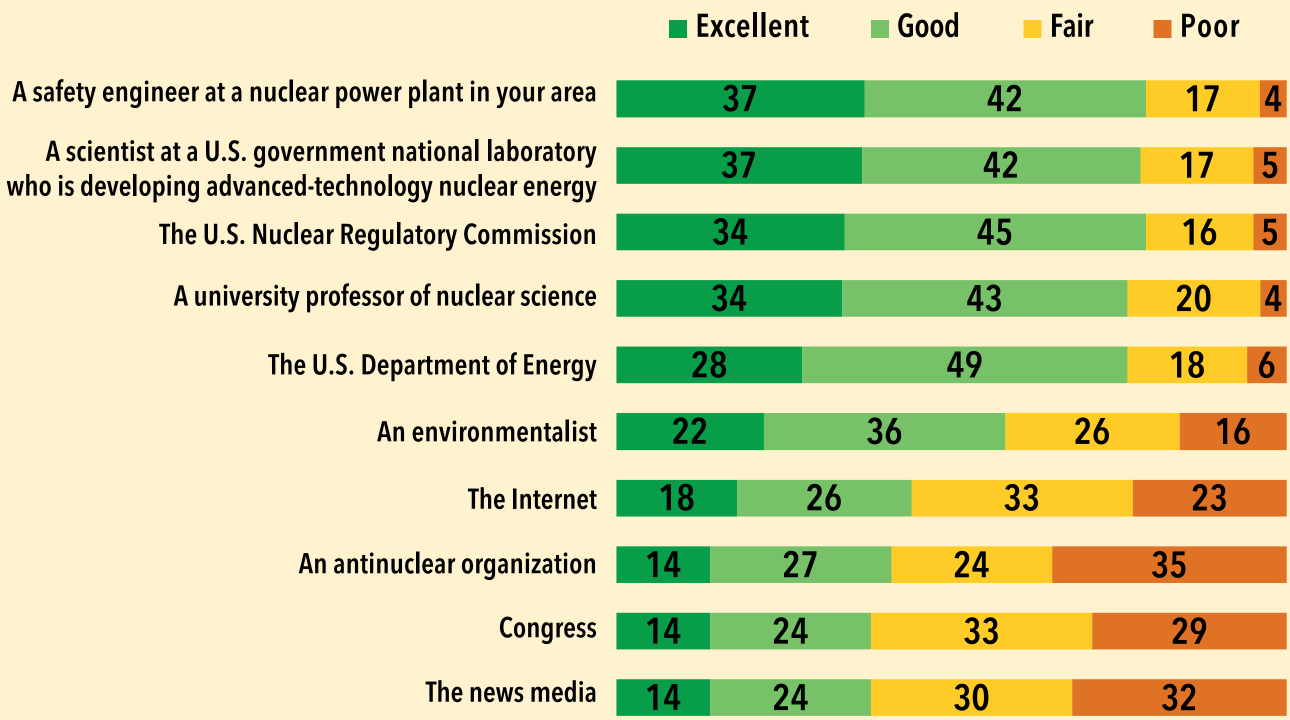
Most Important Considerations for Electricity Production

Select the two considerations for the way electricity is produced that are most important to you. (%)



Credibility of Sources: Experts Trusted Most

In your opinion, would each of the following be an excellent, good, fair, or poor source for accurate information on nuclear energy? (%)



Information impact

Information has a large impact on attitudes toward nuclear energy, as indicated in the previous section. This survey went in depth to bear out that assertion. Information impact was measured in two ways at the end of the interview—*after* questions about attitudes. First, the survey tested the impact of a statement. Respondents were asked about how much they perceived nuclear energy as a reliable energy source and a clean-air energy source. They were then shown this statement and asked how it affected their opinion of nuclear energy:

In fact, nuclear energy is America's largest and most reliable clean-air energy source. Nuclear energy already produces more than half the zero-emission electricity in the United States, and it produces electricity reliably 24 hours a day.

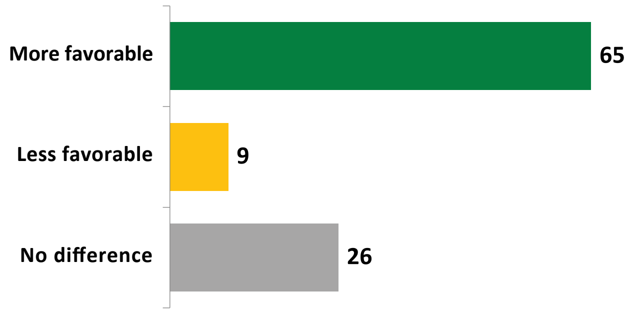
About two-thirds of respondents (65 percent) said this statement made them more favorable toward nuclear energy; 71 percent were Biden voters and 64 percent were Trump voters.

Second, the survey asked respondents to rate the importance of seven "environmental advantages of current or future nuclear power plants." They then selected the two most important advantages, with clean air and clean drinking water their top picks.

Impact of Statement:

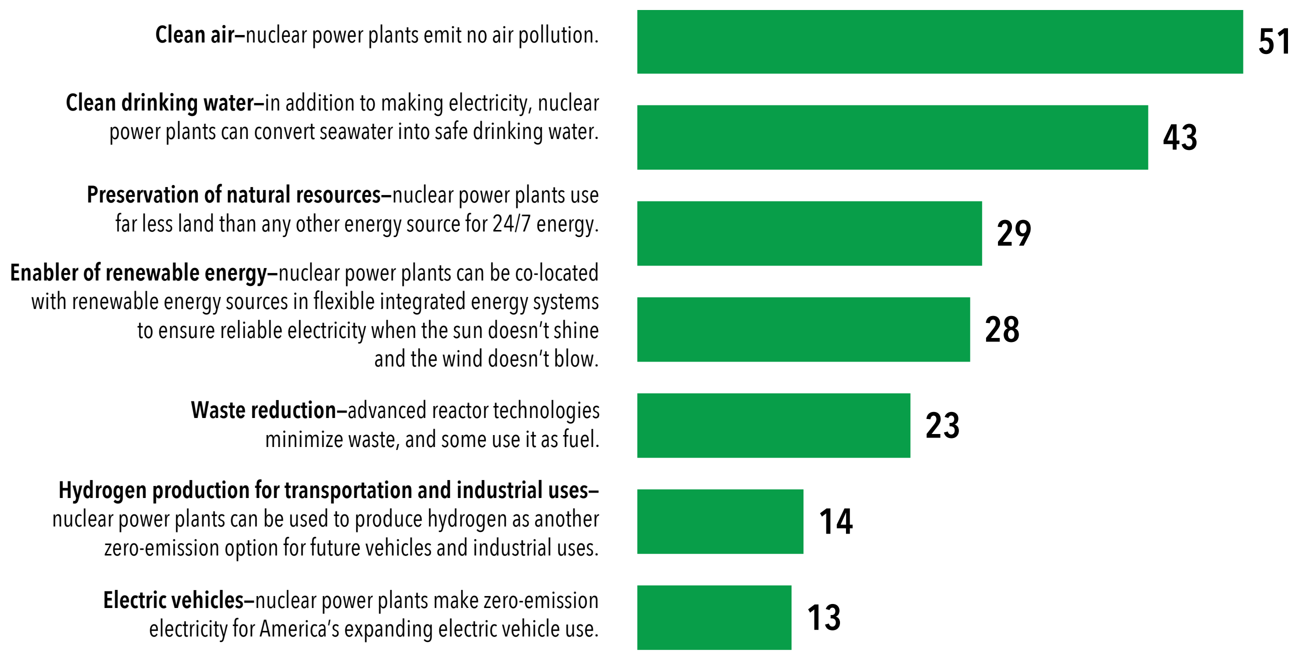
"Nuclear Energy is America's Largest and Most Reliable Clean-Air Energy Source…"

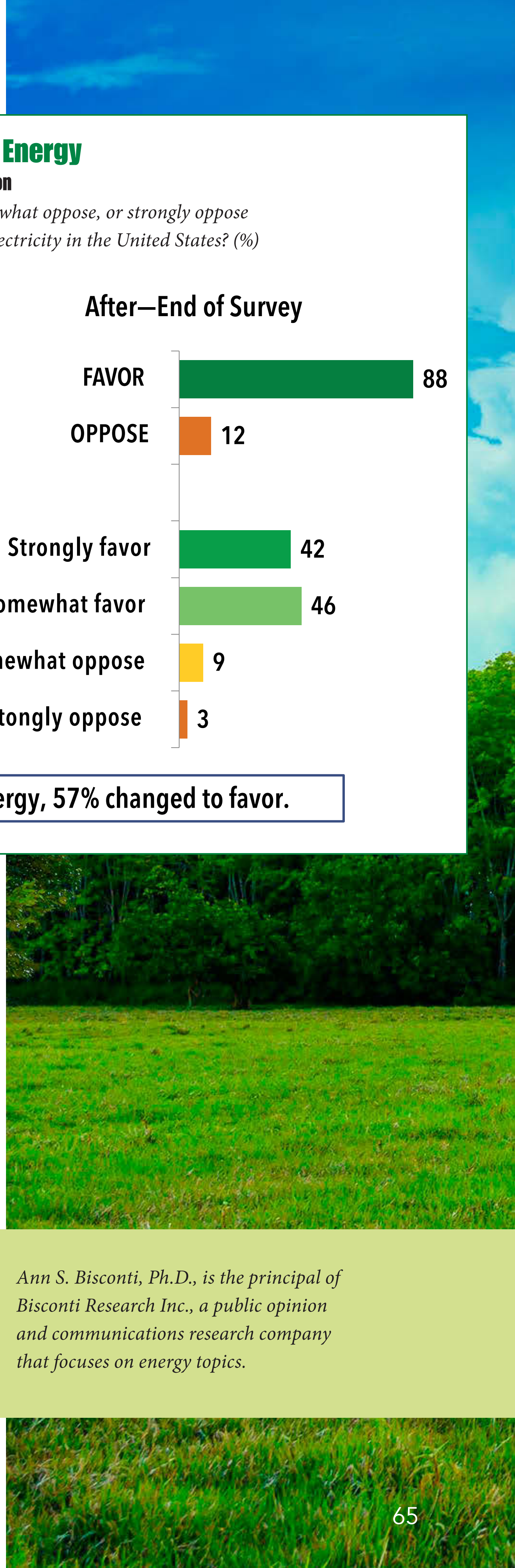
Statement*: In fact, nuclear energy is America's largest and most reliable clean-air energy source. Nuclear energy already produces more than half the zero-emission electricity in the United States, and it produces electricity reliably 24 hours a day. How does this fact affect your opinion of nuclear energy? (%)*

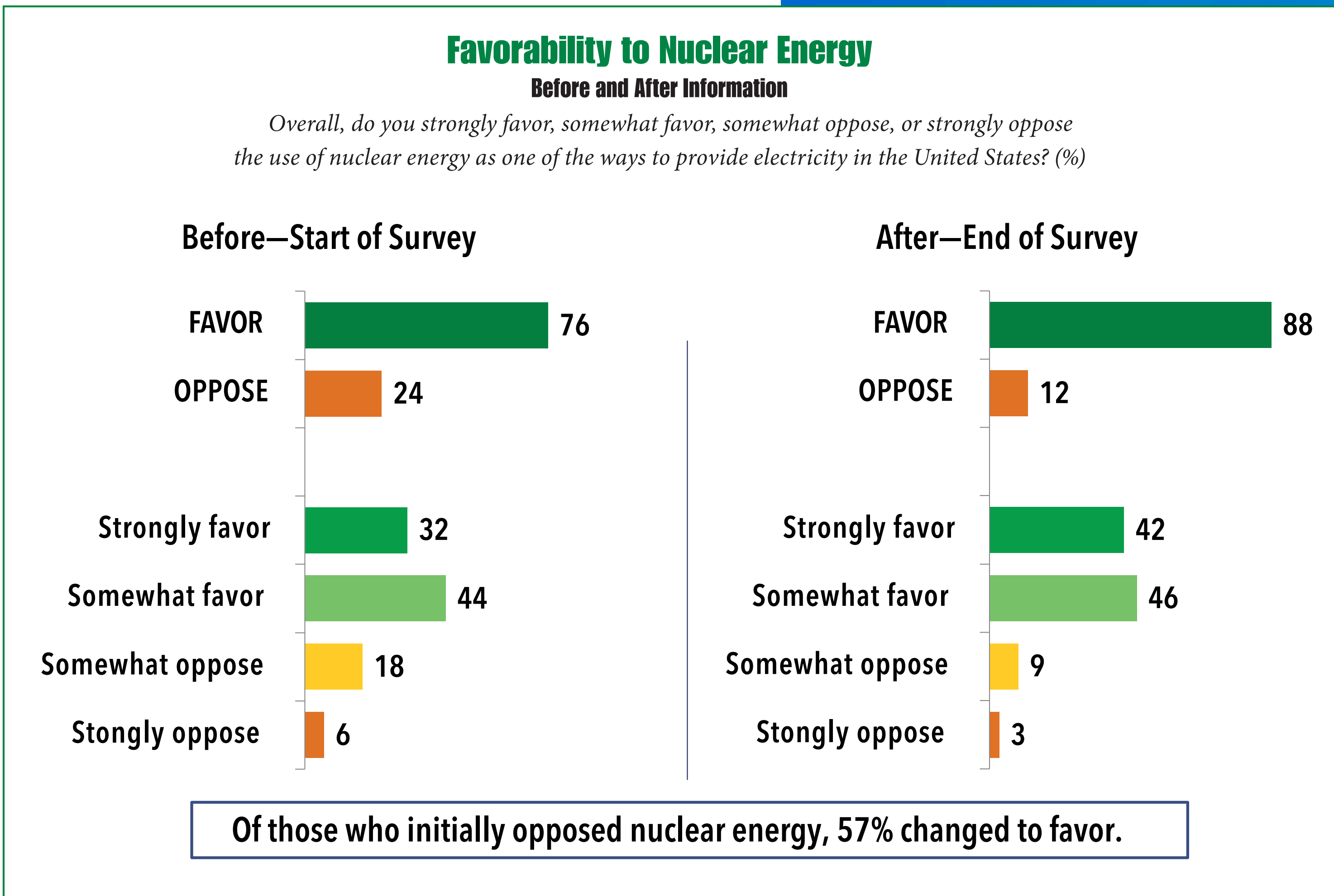


Most Important "Environmental Advantages of Current or Future Nuclear Power Plants"

Select the two environmental advantages of current or future nuclear power plants that are most important, in your opinion. (%)







Following this information, the same favorability question that had been asked at the beginning of the survey was repeated. The number of respondents favoring nuclear energy increased to 88 percent. Those strongly in favor increased from 32 percent to 42 percent. Of those who initially opposed nuclear energy, more than half shifted to favoring it.

Conclusion

The attitude bump found in this survey could be expected, based on the importance given these days to reaching zero-carbon goals and the inclusion of nuclear energy in conversations about solutions. The dramatic shifts in opinion that resulted from the provision of information at the end of the survey show that the magnitude of nuclear energy's clean-air role is not yet well known.

Ann S. Bisconti, Ph.D., is the principal of Bisconti Research Inc., a public opinion and communications research company that focuses on energy topics.

FY 2022 budget proposal supports nuclear

The Biden administration's proposed budget for fiscal year 2022, released in late May, would move the United States toward net-zero carbon emissions by 2050. In pursuit of that goal, the request includes a record $1.85 billion for the Department of Energy's Office of Nuclear Energy, an increase of more than 23 percent from the FY 2021 enacted budget.


Biden

More than $1 billion of the proposed amount is dedicated to nuclear energy research, development, and demonstration programs, including $245 million to support the demonstration of two advanced reactor technologies within the next six years. Also included is funding to support a consent-based siting process related to consolidated interim storage for the nation's used nuclear fuel and high-level radioactive waste.

"President Biden's budget request puts America in the driver's seat as we transition toward a 100 percent clean energy economy," said secretary of energy Jennifer Granholm on May 28. "These investments will ensure the U.S. is the global leader in research, development, and deployment of critical energy technologies to combat the climate crisis, create good-paying union jobs, and strengthen our communities in all pockets of America."

On June 3, Craig Piercy, the American Nuclear Society's executive director and chief executive officer, weighed in on the proposal, stating, "As the scientific and professional organization for over 10,000 nuclear engineers and technologists in the U.S., we applaud the administration's support for federal investments in advanced nuclear energy and tax credit mechanisms for our existing fleet of carbon-free nuclear power plants."

Additional requests

The FY 2022 proposal for research, clean energy, and mission-critical initiatives at the DOE also includes the following:

■ *National laboratories and universities*: The administration requests $7.4 billion for the Office of Science to support foundational research for next-generation energy technologies, including a nearly 10 percent increase in funding for climate and clean energy–focused research. "These investments coupled with investments in applied energy programs would leverage the tremendous innovation capacity of the national laboratories, universities, and entrepreneurs to transform America's power, transportation, buildings, and industrial sectors to achieve a net-zero-emissions economy by 2050," the DOE stated. Funds would also be used to build on and advance the DOE's global leadership in critical technology areas, such as quantum science, advanced supercomputing, and artificial intelligence.

■ *U.S. nuclear security*: The proposal's $19.7 billion request sustains FY 2021 program funding levels for the National Nuclear Security Administration. The request would support critical infrastructure investments, including facilities that will produce plutonium pits for the U.S. nuclear deterrent, the DOE said, adding that $7.6 billion of the total would maintain the nation's investment in cleanup of World War II and Cold War nuclear sites.

■ *Innovation and job creation*: The request of $4.7 billion for the DOE's Office of Energy Efficiency and Renewable Energy, a 65 percent increase from FY 2021, includes more than $1 billion in new funding to deploy clean energy technologies that can "deliver pollution-free, affordable energy to all Americans while creating jobs and building a more equitable economy," according to the DOE. This measure includes two new Manufacturing USA institutes associated with building clean energy technology, $300 million for grants to partner with state and local governments to advance clean energy policies, $400 million to create jobs renovating homes to save energy and reduce energy bills for low-income Americans, and $400 million to create union jobs decarbonizing federal buildings.

The Biden budget also requests $400 million for a new Office of Clean Energy Demonstrations to keep bringing innovative technologies to market. Of note, it provides $327 million to the Office of Electricity to accelerate the modernization of the nation's electrical power grid infrastructure "through planning and other work to promote transmission deployment, advancing technology and systems development to integrate clean energy, and a $119 million investment in grid storage technology," the DOE said.

■ *Energy security and resiliency*: The FY 2022 $201 million budget request would strengthen the Office of Cybersecurity, Energy Security, and Emergency Response's risk management, situational awareness, and emergency response capabilities, according to the DOE. It would also advance policies, technologies, and initiatives to increase the visibility of physical and cyber threats in the operational technology environment; enhance the cybersecurity supply chain; and support exercises and partnerships with states and other public and private sector organizations to bolster U.S. energy security and resiliency.

ADVANCED REACTORS

TerraPower's Natrium demo headed to Wyoming

TerraPower has a design for a sodium-cooled fast reactor and federal cost-shared demonstration funding from the Department of Energy. Its partner, PacifiCorp, has four operating coal-fired power plants in the state of Wyoming. On June 2, together with Wyoming Gov. Mark Gordon and others, the companies announced plans to site a Natrium reactor demonstration project at a retiring coal plant in Wyoming, with a specific site to be announced by the end of 2021.

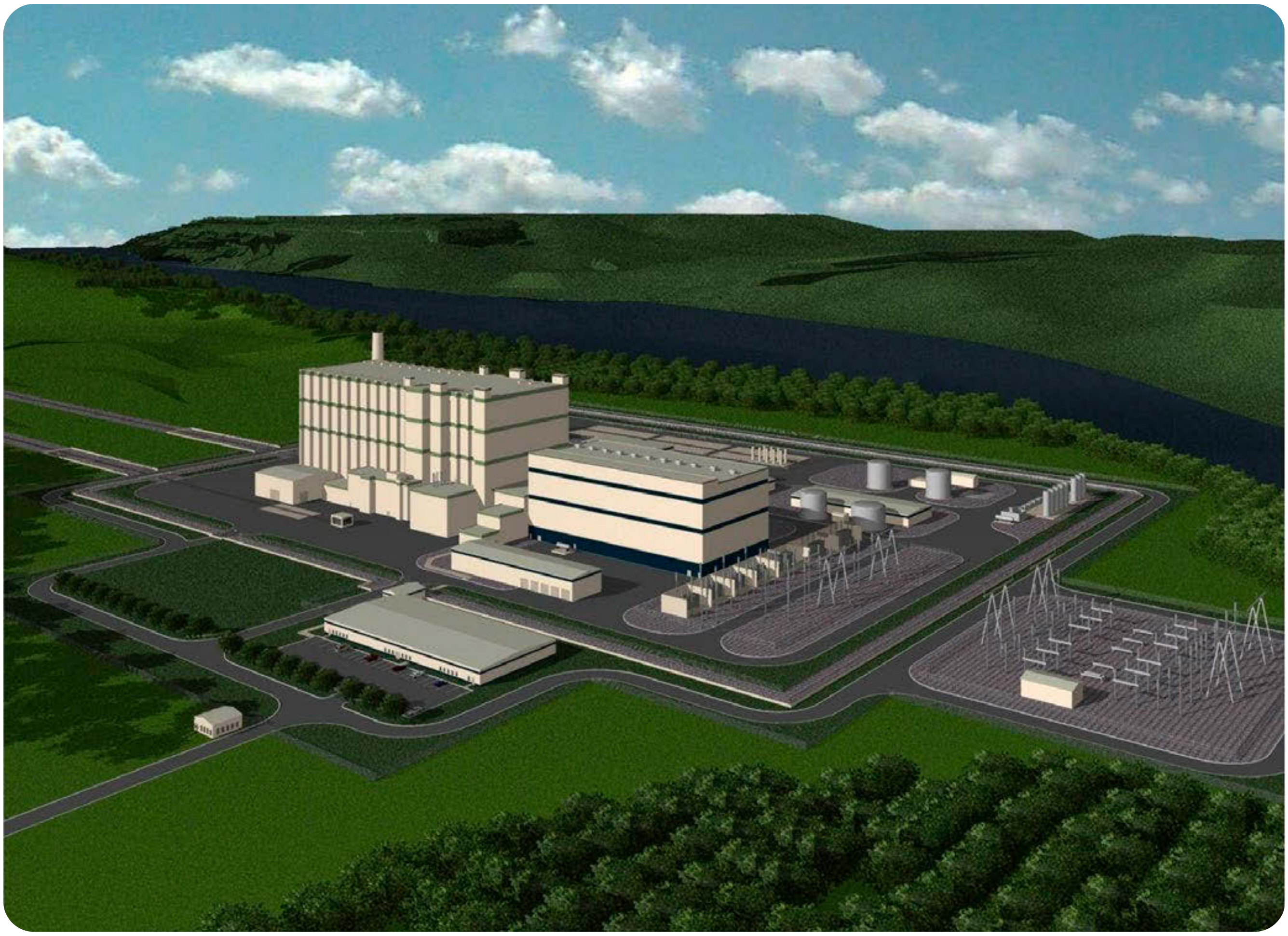
In October 2020, the DOE awarded TerraPower $80 million in initial funding to demonstrate its Natrium technology, which was developed by TerraPower and GE Hitachi, through the DOE's Advanced Reactor Demonstration Program (ARDP). TerraPower signed a cooperative agreement with the DOE in May 2021.

A TerraPower representative confirmed to *Nuclear News* that the company expects the Wyoming demonstration reactor "to be operational later this decade in alignment with the ARDP schedule." The original ARDP schedule called for demonstration reactors to be operating in 2027.

X-energy, the other advanced reactor developer selected by the DOE for ARDP funding, announced on April 1 that it would site its demonstration reactor on an Energy Northwest site near Richland, Wash. Energy Northwest is a partner with TerraPower, as well as with X-energy, and Washington state had been considered a possible destination for the TerraPower demonstration project as well. TerraPower is headquartered in Bellevue, Wash.

"Nuclear power is clearly a part of my all-of-the-above strategy for energy in Wyoming," said Gordon as he kicked off a livestreamed announcement on June 2 that included statements from energy secretary Jennifer Granholm and TerraPower founder Bill Gates. "This plant has the potential to deliver many positive outcomes to Wyoming and her people."

Power & Operations continues



A future TerraPower plant visualization. (Graphic: TerraPower)

Gordon credited the Wyoming legislature with establishing the framework for the project by passing House Bill 74, which permits the development of nuclear power plant regulations by the state's Department of Environmental Quality.

"This project is an exciting economic opportunity for Wyoming," said Gary Hoogeveen, president and chief executive officer of Rocky Mountain Power, a division of PacifiCorp. "Siting a Natrium advanced reactor at a retiring Wyoming coal plant could ensure that a formerly productive coal generation site continues to produce reliable power for our customers."

Next steps for the utility include further project evaluation, education and outreach, and state and federal regulatory approvals. "We are currently conducting joint due diligence to ensure this opportunity is cost-effective for our customers and a great fit for Wyoming and the communities we serve," Hoogeveen added.

Natrium technology

The demonstration project, which is intended to validate the design, construction, and operational features of the Natrium technology, will be a full-size 345-MW sodium-cooled fast reactor with a molten salt–based energy storage system. Natrium's storage technology can boost the system's output to 500 MW of power for more than five-and-a-half hours when needed to integrate with variable renewable energy sources.

Along with PacifiCorp, GE Hitachi Nuclear Energy, and Energy Northwest, members of the TerraPower demonstration project team include engineering and construction partner Bechtel, Duke Energy, and nearly a dozen additional companies, universities, and national laboratory partners.

NuScale to explore SMR deployment in central Washington

An artist's rendering of the NuScale plant. (Image: NuScale)

Portland, Ore.–based NuScale Power has announced the signing of a memorandum of understanding with the Grant County Public Utility District (Grant PUD) to evaluate the deployment of NuScale's advanced nuclear technology in central Washington state.

Based in Ephrata, Wash., the Grant PUD is a public electric utility serving more than 40,000 retail power customers in Grant County. The utility's two Columbia River dams (Priest Rapids and Wanapum) and smaller hydropower projects have a generating capacity of more than 2,100 megawatts.

In its May 26 announcement, NuScale noted that its power plant design, the NuScale Power Module, is scalable in 77-MWe increments up to 924 MWe (12 units). "Modules can be added incrementally as regional load demands increase, offering the customer a new level of flexibility and reduced financial risk," NuScale said. "These qualities align well with Grant PUD's long-term objective of providing its customers with reliable, carbon-free energy."

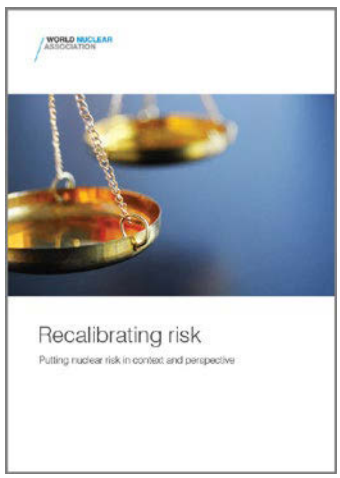
According to a NuScale/Grant PUD frequently-asked-questions document, the utility projects that the demand for power will exceed its hydropower generation resources during seasonal peak times by 2026. "NuScale's small modular reactor technology, with its carbon-free, reliable power, provides a promising generation resource," the document states. "Grant PUD is excited to pursue this technology as it determines how it will serve the power needs of its growing customer base."

RISK ASSESSMENT

WNA calls for all-hazards approach to nuclear power

The World Nuclear Association has issued a white paper advising the world's policymakers and regulators to adopt a science-based, all-hazards risk assessment and management system that holistically evaluates the contributions of different energy sources and sets a level playing field.

The paper, *Recalibrating Risk: Putting Nuclear Risk in Context and Perspective*, states that disproportionately focusing on the risks posed by radiation can result in the acceptance of other, more significant risks. For example, the WNA says, while air pollution from heavy fossil fuel use worldwide has caused the early demise of millions, severely damaged the environment, and exacerbated climate change, nuclear power is routinely ostracized and its substantial contributions to global decarbonization disregarded.



"Nuclear technologies can contribute enormously toward tackling two of the biggest challenges facing the world today—the decarbonization of the global economy and fulfilling the [United Nations'] sustainable development goals for everyone—but are being held back because of the many misconceptions about nuclear energy," said WNA director general Sama Bilbao y León. "Indeed, as recently highlighted by the International Energy Agency

Power & Operations continues

in its net-zero report, nuclear energy is a crucial component in ensuring the deep decarbonization needed to meet the 1.5°C target. To fully unlock the potential of nuclear power, a global paradigm shift is needed—one that is led by scientific evidence and evaluates the risks associated to all economic activities holistically, without overemphasizing one kind of risk over another."

UNITED KINGDOM

British nuclear joins renewables to press for grid decarbonization

Three United Kingdom organizations—the Nuclear Industry Association, RenewableUK (formerly the British Wind Energy Association), and Solar Energy UK—are calling for urgent action to build new nuclear, wind, and solar capacity and for a binding target of 100 percent grid decarbonization by 2035.

The United Kingdom was the first of the world's major economies to embrace a legal obligation to achieve net-zero carbon emissions by 2050.

With the COP26 summit in Glasgow, Scotland, just a few months away, the British grid is "dirtier now than it was a year ago, with heavy reliance on fossil fuels," according to a May 20 joint statement from the organizations.

The three zero-carbon energy allies cite data from the National Grid ESO, Great Britain's electricity system operator, showing that the carbon intensity of electricity—the measure of CO_2 emissions per unit of electricity consumed—was some 5 percent higher in the first four months of 2021 compared with the first four months of 2020. Gas-fired generation was 22 percent higher, even though the nation spent more weeks under COVID-19 restrictions from January to April 2021 than in the same period in 2020. "Despite individual record-breaking days, the grid was on average 20 percent dirtier in April 2021 than in April 2020, with a carbon intensity of 200 gCO_2/kWh," the statement says.

To accelerate progress toward decarbonization, the organizations are recommending an increase in the carbon price that would be consistent with delivering grid decarbonization by 2035. Trading of carbon allowances on the United Kingdom's post-Brexit carbon market began on May 19, with carbon prices reaching more than £50 (about $71) per metric ton, higher than in the European Union.

In addition, each organization has its own recommendation:

■ The NIA is calling for the government to endorse a financing model for new nuclear projects this year and to set out a plan to restore nuclear capacity to existing levels by the early 2030s.

■ RenewableUK is looking to the government to set specific 2030 deployment targets for key renewable technologies that it represents: 30 GW of onshore wind, 2 GW of floating wind, and 5 GW of green hydrogen electrolyzer capacity, in addition to 1 GW of marine energy in the 2030s.

■ Solar Energy UK is calling for a specific government target of 40 GW of solar deployment by 2030. To support this, the group says, the government should reinstate funding and end the value-added tax for green home upgrades, reform business rates for large solar roofs, and provide annual contract-for-differences auctions for solar until the end of the decade.

"We need to invest in a new generation of nuclear stations to hit net zero and help level up the country," said NIA chief executive Tom Greatrex. "We know that nuclear and renewables work well together to cut emissions, and that strong low-carbon energy mix is our future."

Artist's conception of the UK SMR consortium's small modular reactor. (Image: Rolls-Royce)

Consortium debuts new SMR design

The UK SMR consortium on May 17 revealed the latest design and power upgrade—from 440 MW to 470 MW—for its proposed small modular reactor. According to the consortium's lead company, Rolls-Royce, the "refreshed" design features a faceted roof, an earth embankment surrounding the reactor to integrate with the landscape, and a more compact building footprint.

Power & Operations continues

The design's unveiling came two weeks after the United Kingdom's Department for Business, Energy, and Industrial Strategy opened the generic design assessment (GDA) to advanced reactor technologies. The consortium is aiming to have its SMR design the first to be assessed by U.K. regulators, in the second half of 2021, and it hopes to complete its first unit by the early 2030s and its 10th by 2037.

GDA is performed by the Office for Nuclear Regulation (ONR) and the Environment Agency (EA) to gauge the safety, security, and environmental protection aspects of a nuclear plant design. Successfully completing the GDA culminates in a design acceptance confirmation from the ONR and a statement of design acceptability from the EA.

The consortium expects its SMR program to:

- Create 40,000 regional U.K. jobs by 2050.
- Generate £52 billion (about $73.3 billion) of economic benefit.
- Source 80 percent of a plant's components from the United Kingdom.
- Target an additional £250 billion (about $354.2 billion) of exports (memoranda of understanding are already in place with Estonia, Turkey, and the Czech Republic).
- Initially cost £2.2 billion (about $3.1 billion) per unit, dropping to £1.8 billion (about $2.5 billion) by the time five have been completed.
- Operate for at least 60 years.

"Nuclear power is central to tackling climate change, securing economic recovery, and strengthening energy security," said Tom Samson, the consortium's chief executive officer. "To do this, it must be affordable, reliable, and investable, and the way we manufacture and assemble our power station brings down its cost to be comparable with offshore wind at around £50 per megawatt-hour."

CANADA

Moltex clears first phase of CNSC vendor design review

The Canadian Nuclear Safety Commission (CNSC) has completed phase one of its prelicensing vendor design review (VDR) for Moltex Energy's 300-MW Stable Salt Reactor–Wasteburner (SSR-W)—a molten salt reactor that uses nuclear waste as fuel. CNSC entered into an agreement with Moltex in November 2017 to conduct the initial phase of the review.

An optional service, the VDR is a high-level review of a proposed reactor technology's design information against Canadian regulatory requirements and guidance. The service does not involve the issuance of a license and is not part of the licensing process. A phase-one VDR determines whether, at a general level, the vendor's reactor design and design processes demonstrate implementation of CNSC regulatory requirements.

According to the CNSC's May 25 executive summary of the SSR-W's VDR, Moltex has a clear understanding of the Canadian regulatory requirements and expectations.

"Completing phase one of the VDR is a major achievement," said Rory O'Sullivan, chief executive for Moltex Energy, North America. "This demonstrates that our technology is progressing in the right direction and gives current and future customers confidence in our design of advanced nuclear reactors."

Offering governmental congratulations on the accomplishment was Mike Holland, natural resources and energy minister for New Brunswick, one of several Canadian provinces that have expressed an interest in advanced reactor development. "This is a significant milestone, and I look forward to your continued success as you move through the CNSC's regulatory process," Holland said.

In March of this year, the Canadian government awarded C$50.5 million (about $40.2 million) to Moltex Energy Canada to support small modular reactor research and technology development in New Brunswick. The investment was provided by the government's Strategic

Innovation Fund and its Regional Economic Growth Through Innovation program, part of the Atlantic Canada Opportunities Agency.

In a press release on the funding, Moltex said it plans to build the world's first SSR-W and Waste to Stable Salt facility at the site of the Point Lepreau nuclear plant in Saint John, New Brunswick, and to provide electricity to the grid by the early 2030s.

Micro Modular Reactor reaches licensing milestone

Global First Power's (GFP) Micro Modular Reactor (MMR) project has moved to the formal license review phase with the Canadian Nuclear Safety Commission (CNSC), becoming the first small modular reactor to do so.

As explained in GFP's May 19 announcement, the company now moves closer to its 2026 goal of building, owning, and operating Canada's first SMR. The proposed 15-MWt (approximately 5-MWe) high-temperature, gas-cooled reactor is to be sited at Chalk River Laboratories, operated by Canadian Nuclear Laboratories (CNL).

Power & Operations continues

Artist's rendering of the MMR project. (Image: USNC)

GFP is a joint venture formed by USNC-Power, a Canadian subsidiary of Seattle-based Ultra Safe Nuclear Corporation (USNC), and Ontario Power Generation.

In April, CNL announced that it had fabricated fully ceramic microencapsulated (FCM) fuel pellets, a proprietary reactor fuel designed by USNC for its MMR. The FCM project, funded through the Canadian Nuclear Research Initiative, represents the first time that tristructural isotropic (TRISO) fuel has been manufactured in Canada, CNL said.

According to USNC, the MMR's energy system integrates "one or several standardized microreactors with a heat storage unit and the adjacent plant for power conversion and utilization. Electrical power or process heat (or a mix of both) is produced in the energy system, depending on configuration. Nuclear heat is transferred from the microreactors to a molten salt energy storage unit that decouples the nuclear system from the power utilization system, greatly simplifying operations and allowing flexible use of the energy generated." The system can be used to provide high-quality process heat for colocated industrial applications and for high-efficiency hydrogen production, USNC added.

POLAND

Westinghouse to open global service center in Kraków

After declaring its intention earlier this year to invest in nuclear technologies in Poland, Westinghouse Electric Company on May 24 announced the establishment of a "world-class" global shared service center in Kraków.

The new location, Westinghouse's first in Poland, is scheduled to open in Zablocie Business Park B in August 2021. In its first stage, the center will employ nearly 150 skilled workers in various functions supporting the global organization of Westinghouse.

"Westinghouse is well-positioned to help Poland meet its energy goals through in-country investments in nuclear technologies," said Patrick Fragman, the company's president and chief nuclear officer. "High-quality, in-country talent will expand our diverse team of more than 9,000 employees across the world and help Westinghouse to play an even stronger role in Poland's viable energy industry, while also leveraging our Polish capabilities in the rest of the world."

In its announcement, the company touted its AP1000 technology, stating that it "would not only provide Poland with clean and carbon-free energy and greater energy security, but also a vast amount of qualified and durable jobs in-country through the nuclear supply chain networks and during the whole lifetime of the operating plants."

Kraków's Zablocie Business Park B. (Photo: OfficeMAP)

PAKISTAN

First Hualong One unit outside of China enters commercial operation

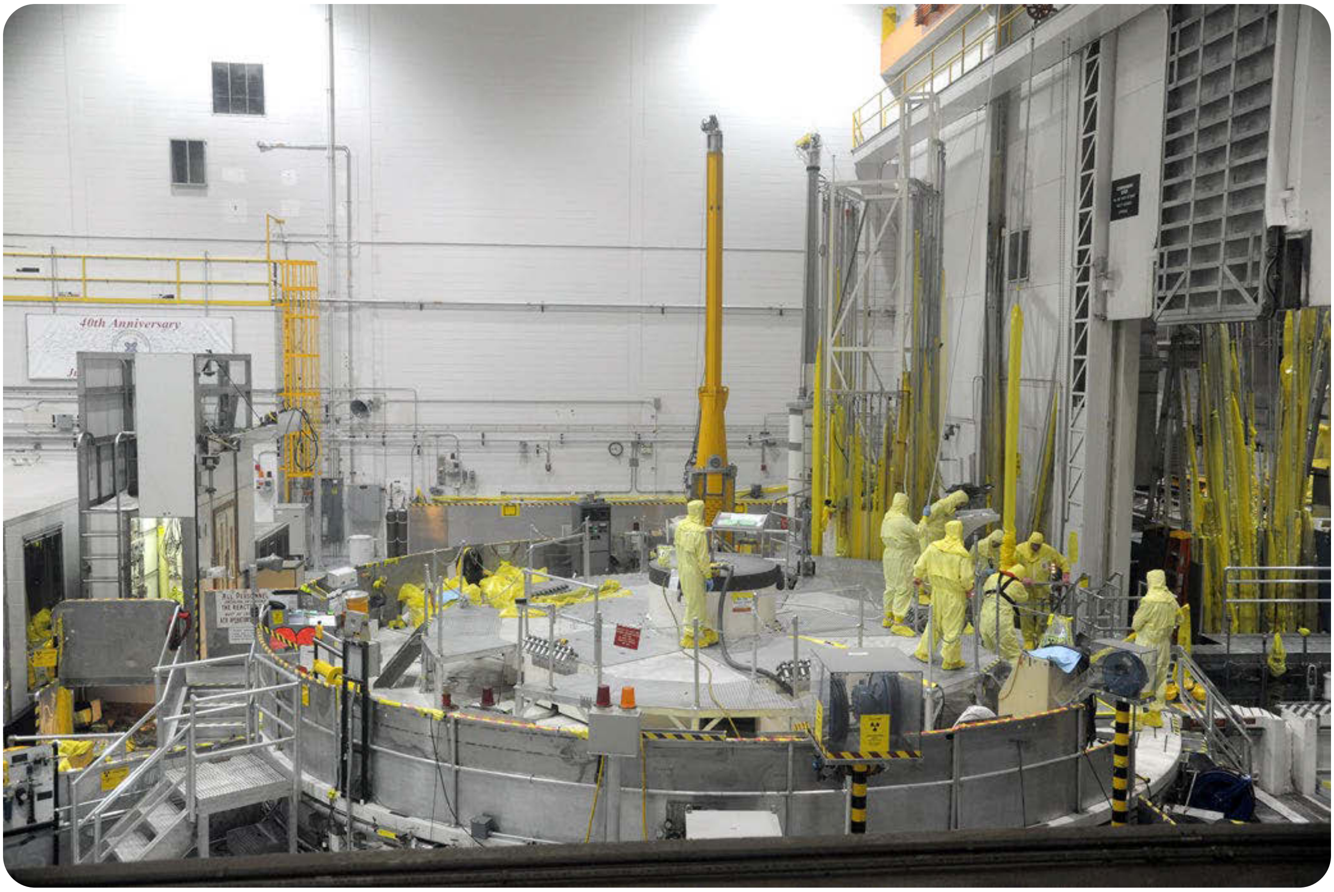
Unit 2 at Pakistan's Karachi nuclear power plant officially began commercial operation in late May, gaining the distinction of being the first Hualong One reactor outside of China to do so. Construction of Karachi-2 began in August 2015, and connection to the grid was accomplished in March of this year.

China National Nuclear Corporation announced the commercial start of the very first Hualong One—Unit 5 at the Fuqing nuclear plant in China's Fujian Province—in late January. Also known as the HPR1000, the Hualong One is a Chinese-designed and -developed 1,000-MWe Generation III pressurized water reactor, incorporating design elements of CNNC's ACP1000 and China General Nuclear's ACPR1000+. The Hualong One has a design life of 60 years.

The Karachi plant, located in southern Pakistan on the Arabian Sea coast, also houses Unit 1, a 90-MWe CANDU pressurized heavy water reactor that has been in operation since 1972, and Unit 3, a Unit 2 twin, which is scheduled to start commercial operation early next year.

Karachi-2 and -3 are each expected to generate approximately 9 billion kWh of electricity per year, meeting the annual demand of electricity of more than 4 million households in Pakistan—equivalent to reducing standard coal consumption by 3.12 million tons, cutting carbon dioxide emissions by 8.16 million tons, or planting more than 70 million trees, according to CNNC.

Project construction has also boosted the development of Pakistan's economy and relevant Pakistani industries, CNNC said, directly providing more than 10,000 job opportunities for Pakistan's citizens and creating a further 40,000 job opportunities through the value chain.



The ATR prepares for continued operation and increased capacity

Above: Operations personnel working above the Advanced Test Reactor on the reactor top area. The small cylindrical section in the center of the platform has access ports for refueling and experiment loading and unloading during routine outages. (Photo: INL)

The Advanced Test Reactor (ATR) at Idaho National Laboratory is getting an overhaul that will keep it off line for nine months. When the ATR is restarted in early 2022, the one-of-a-kind pressurized water test reactor—which is operated at low pressures and temperatures as a neutron source—will be ready for another decade or more of service, with the potential for more experimental capacity in years to come.

The neutrons produced by the ATR are in high demand, especially since the permanent shutdown of Norway's 60-year-old Halden reactor in June 2018. Studying how fuel and material samples respond to a high-neutron environment gives researchers data on how new materials and designs will perform during long-term operations in high-radiation environments.

The ATR fulfills missions for the U.S. Navy and the Department of Energy's Office of Nuclear Energy, produces radioisotopes for nuclear medicine and NASA space missions, and supports university and industry researchers from the United States and around the world. Pressure has grown to expand the testing capacity of the ATR, which is already in its sixth decade of operations.

The ATR was designed to require a core internals changeout (CIC) about every 10 years, and during this outage, the sixth CIC since the reactor began operations in 1967, critical work is being done to permit the addition of more experiment space, as proposed in a report, *Post-Halden Reactor Irradiation Testing for ATF: Final Recommendations*, published by INL in December 2018. The addition of one or two I-loops in the ATR would allow for more testing of advanced light water reactor fuels.

"We are doing some preparatory work during this CIC that will enable the addition of more experiment loop capacity," INL spokesperson Joe Campbell told *Nuclear News*. "The preparatory work involves the installation of a new component on the top of ATR's reactor vessel lid, called the top head closure plate. It's an important step that can only be done during a CIC outage."

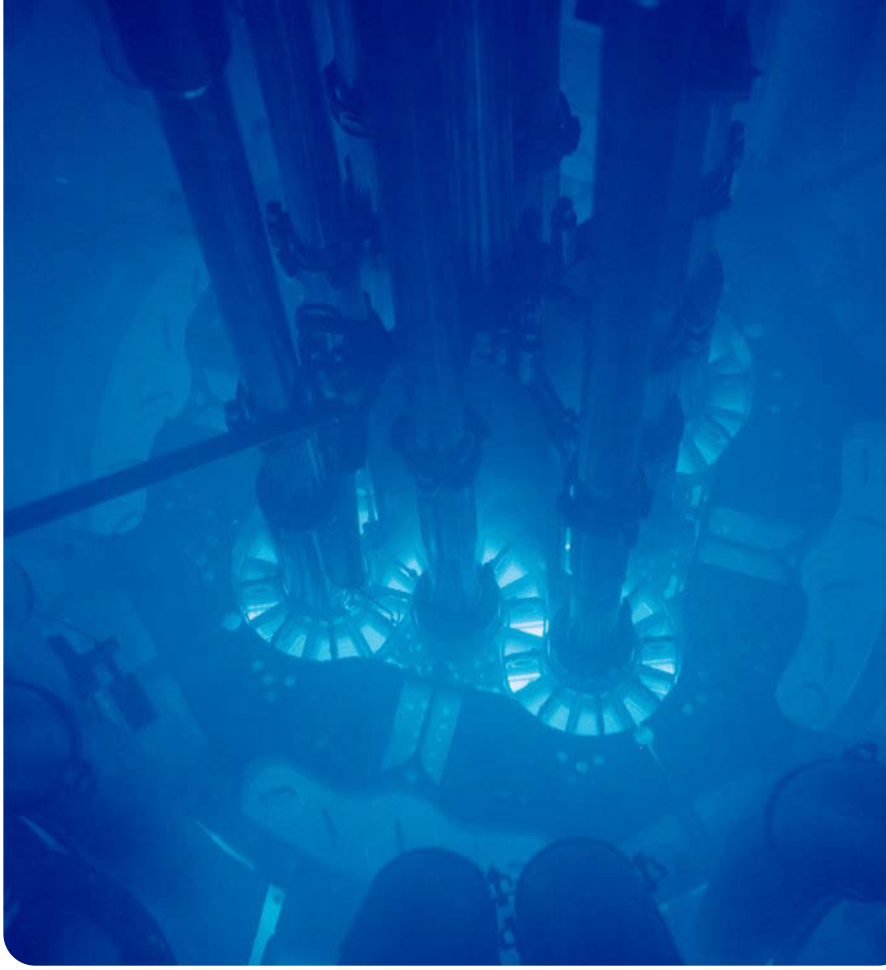
The new top head closure plate will feature eight new peripheral penetrations to provide access for more testing capacity. "At this time, one additional loop is planned, which is scheduled to come online as early as 2023," Campbell said. "This will enable ATR to provide even more capability and flexibility to meet the growing demand for irradiation test space caused by the Halden shutdown."

That's good news for researchers and nuclear fuel developers. Lightbridge Corporation president and chief executive officer Seth Grae is eager to see near-term federal investment to take advantage of the new access points and rapidly expand the ATR's testing capacity to allow for accelerated testing of advanced fuels.

Nuclear News spoke with Grae and other Lightbridge representatives, including Aaron Totemeier, vice president of fuel cycle technology and fuel fabrication, and James Fornof, vice president of nuclear program management, about their plans and requirements for fuel testing.

What makes this the right time to talk about funding, Grae said, "is the unique intersection between the federal funding cycle and the 10-year core internals changeout." Looking for certainty about the Department of Energy's plans to implement new test loops, Lightbridge is encouraging increased federal funding on the order of $35 million.

"Lightbridge and other nuclear vendors can make use of these potentially new capabilities in our R&D efforts almost immediately once available," Grae said. "The lack of these added loops has become a choke point for advanced nuclear development in the United States for competition against Russia and China. I really do think that now is the time."



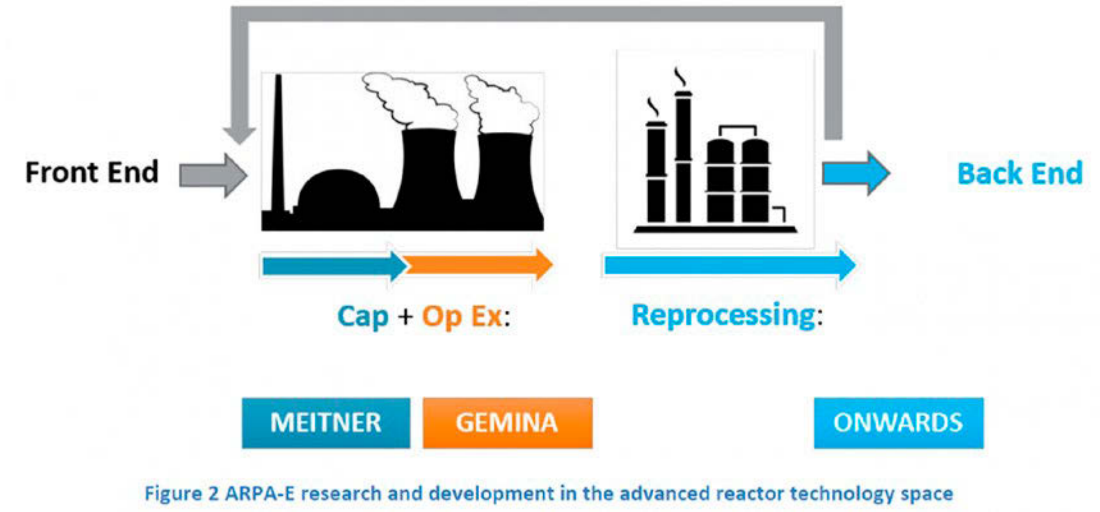
Advanced Test Reactor core. (Photo: INL)

Lightbridge's current work includes designing a drop-in capsule experiment for testing in the ATR, work that is supported by a voucher and a cooperative research and development agreement awarded through the Gateway for Accelerated Innovation in Nuclear. Design work is expected to be completed before the fourth quarter of 2021, and the test capsule could be inserted in late 2022 or early 2023. The experiment will yield information about the basic thermophysical properties and irradiation behavior of Lightbridge fuel, including microstructure evolution, thermal conductivity, and irradiation-induced swelling as a function of burnup.

"This type of test has limited heat removal from the experiment, and prototypic commercial reactor conditions can't be realized," Grae said. "A flow loop experiment will tell us much more. Ultimately, we will need flow loops that can simulate the conditions of the commercial fleet, including PWRs, BWRs, and the water-cooled SMRs under development."

Research & Applications continues

This figure, included in the ONWARDS funding opportunity announcement, shows how ARPA-E R&D programs address different stages of advanced reactor development. (Figure: ARPA-E)



ARPA-E

New funding for advanced reactor fuel cycle and reprocessing R&D

The Department of Energy has announced up to $40 million in funding for a new Advanced Research Projects Agency–Energy (ARPA-E) program to conduct research and development into technologies for reprocessing and ultimately disposing of used nuclear fuel. The program, Optimizing Nuclear Waste and Advanced Reactor Disposal Systems (ONWARDS), targets both open (once-through) and closed (reprocessing) fuel cycles to reduce the amount of waste produced from advanced reactors tenfold when compared to light water reactors.

ONWARDS is ARPA-E's first foray into advanced reactor used fuel disposal pathways since the agency's authority was revised in the ARPA-E Reauthorization Act of 2019, adding a charge to "provide transformative solutions to improve the management, cleanup, and disposal of radioactive waste and spent nuclear fuel."

As advanced nuclear reactor technologies move from research and development phases to deployment through the DOE's Advanced Reactor Demonstration Program, ARPA-E's ONWARDS program will identify and address challenges at the back end of the fuel cycle before advanced reactors are deployed. ONWARDS will complement ARPA-E's existing nuclear energy research portfolio, which includes the MEITNER (Modeling-Enhanced Innovations Trailblazing Nuclear Energy Reinvigoration) and GEMINA (Generating Electricity Managed by Intelligent Nuclear Assets) programs, according to a program announcement made on May 19.

ONWARDS metrics include an order-of-magnitude reduction in advanced reactor waste volume generation or repository footprint compared to light water nuclear reactors, better than 1 percent fissile-mass accountancy in reprocessing streams, development of high-performance waste forms for a variety of potential deep geological repositories and disposal concepts, and costs in the range of $1 per megawatt-hour.

ONWARDS teams will work in three key areas:

- Process: Improvements in fuel recycling that significantly minimize waste volumes, improve intrinsic proliferation resistance, increase resource use, and bolster advanced reactor commercialization.
- Safeguards: Improvements in sensor and data fusion technologies that enable accurate and timely accounting of nuclear materials.
- Waste form: Development of high-performance waste forms for all advanced reactor classes, with an emphasis on those forms that span multiple reactor classes and disposal environments and are safe and stable over required timescales.

The funding opportunity announcement

provides additional details. ARPA-E notes that concepts that address three advanced reactor fuel cycles—TRISO fuel, metallic fuel, and molten salt fuel—are "presently considered most promising." However, other fuel cycle technologies may also be supported, including technologies that are also compatible with commercial LWR fuel cycle wastes. The assumption is that wastes from the back end of the fuel cycle would ultimately be disposed of in geological repositories.

In Case You Missed It—Research & Applications

The world's first atomic bomb test had an unintended product that was only recently discovered. The extreme temperatures and pressures generated by the detonation of the plutonium implosion fission device known as the "Gadget" in New Mexico in 1945 created large amounts of trinitite, a glasslike combination of natural sand and test equipment. Within a small sample of red trinitite, researchers led by the University of Florence recently confirmed the existence of the oldest known anthropogenic quasicrystal—a crystal with atoms arranged as in a mosaic, in regular but nonrepeating patterns. The icosahedral quasicrystal discovered in red trinitite is a previously unknown composition of silicon, copper, calcium, and iron: $Si_{61}Cu_{30}Ca_{7}Fe_{2}$.

Video still showing samples of red trinitite. (Source: University of Florence)

Plutonium found in the deep-sea crust of the Pacific Ocean, together with radioactive iron, is contributing to an understanding of how heavier elements were created from exploding stars and other cosmic events, according to an article and news brief in the May 14 issue of the journal *Science*. By looking at trace amounts of plutonium-244, which does not exist naturally on Earth, with quantities of iron-60, which is known to be the product of supernovae, researchers were able to evaluate models used to predict how the elements are formed through the rapid neutron capture process. The study suggests that supernovae are not the sole source of the heavier elements, adding to a growing body of evidence that colliding neutron stars are responsible for the formation of these materials.

The Crab Nebula. (Image: NASA, ESA, and Allison Loll/ Jeff Hester, Arizona State University)

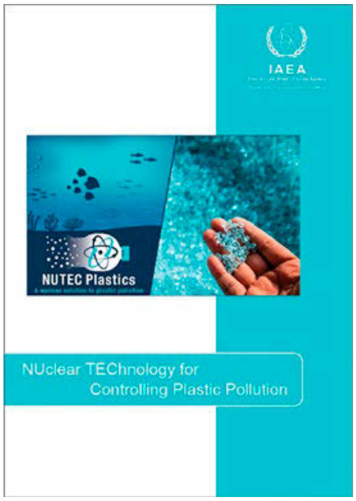
For in-depth coverage of these stories and more, see ANS's* Nuclear Newswire *at ans.org/news.

Research & Applications continues

IAEA

Nuclear techniques to monitor—and prevent—plastic pollution

The International Atomic Energy Agency has created a new program, NUclear TEChnology for Controlling Plastic Pollution (NUTEC Plastics), to address the global environmental impact of plastic pollution in oceans. It uses nuclear technology to monitor pollution and also to decrease the volume of plastic waste by using irradiation to complement traditional plastic recycling methods.



According to the IAEA, the oceans are expected to contain one metric ton of plastic for every three metric tons of fish by 2025, based on current trends, and by 2050 there may be more plastic than fish.

"Nuclear techniques can help in assessing and understanding the dimension of the problem . . . but also in the recycling of plastic through radiation techniques, which allows us to produce materials that can be further used in the concept of a circular economy," said IAEA director general Rafael Mariano Grossi during a roundtable discussion on May 18 with IAEA partners in Asia and the Pacific region. Similar roundtables are planned for other regions, along with technical webinars on relevant nuclear technologies and their application against plastic pollution.

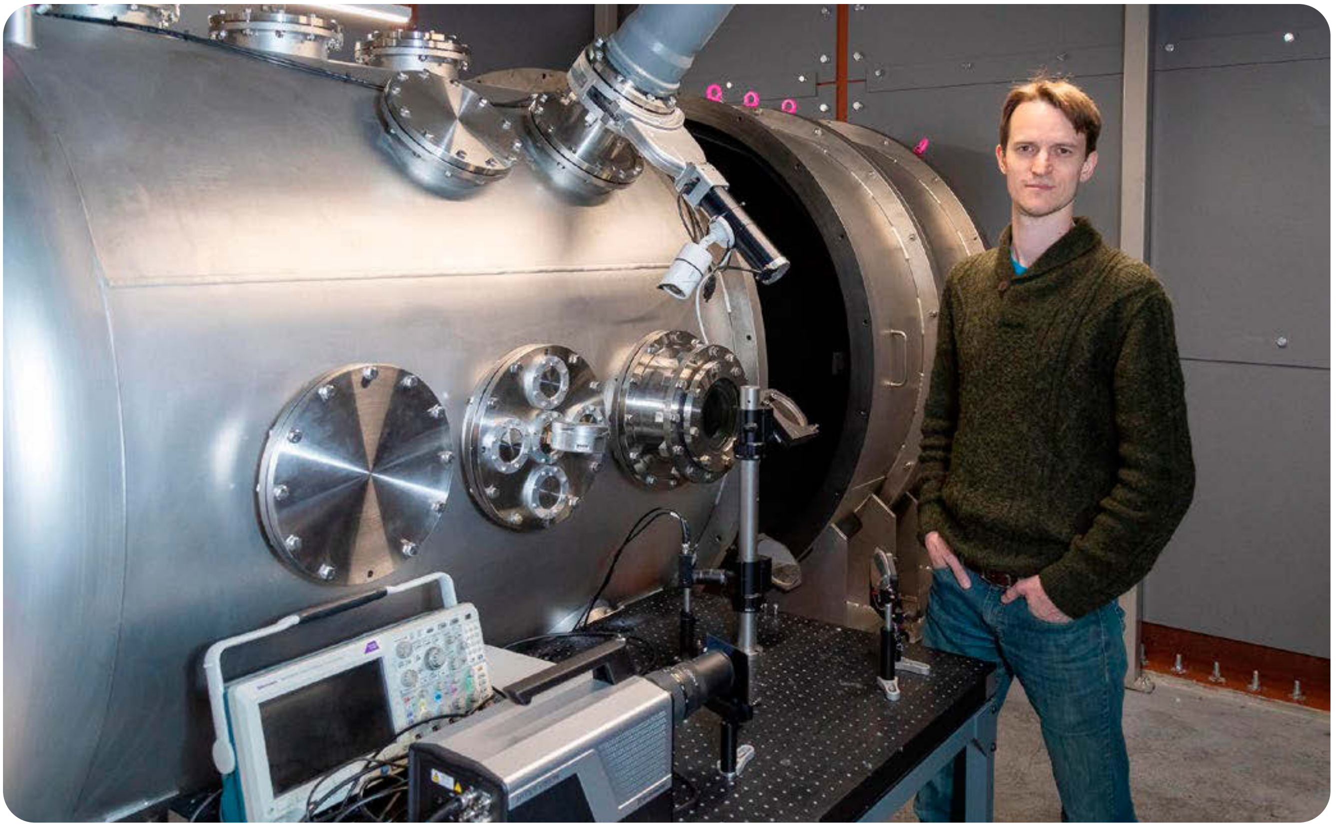
NUTEC Plastics was created to assist countries in integrating nuclear and isotopic techniques to address plastic pollution. Its approach is twofold: (1) to provide science-based evidence to characterize and assess marine microplastic pollution, and (2) to demonstrate the use of ionizing radiation to transform plastic waste into reusable resources.

As a complement to traditional mechanical and chemical recycling methods, NUTEC Plastics will demonstrate how gamma and electron beam radiation technologies can modify certain types of plastic waste to be recycled or upcycled for reuse.

According to documentation from the IAEA, gamma and electron beam irradiation can complement existing recycling methods to:

- Sort mechanically treated plastic waste according to polymer type.
- Break down plastic polymers into smaller components to be used as raw materials for new plastic products.
- Treat plastic so that it can be amalgamated with other material to make more durable products.
- Convert plastic into fuel and feedstocks through radiolysis (irradiation and chemical recycling).

Plastic waste on a Galapagos beach. Sunlight, wind, and waves break down large plastic debris into smaller and smaller pieces to become microplastics. (Photo: F. Oberhaensli/IAEA)



First Light Fusion CEO Nick Hawker stands near the target end of the 22-meter-long gas gun. (Photo: First Light)

FUSION

First Light fires first shots from gun built for pulsed fusion

Inside a new steel-clad facility nicknamed "The Citadel," First Light Fusion has installed a 22-meter, two-stage gas gun—the third-largest such component in Europe.

First Light Fusion, based in Oxford, U.K., announced on May 13 that it has completed construction of the gun as part of its experimental efforts to use inertial confinement fusion to create the extreme temperatures and pressures required for fusion—work the company hopes will lead to commercial fusion energy. First Light has successfully fired the first test shots from the gun; fusion experimental shots were planned for June.

First Light's 38-mm gun, which weighs 25,000 kg and uses up to 3 kg of gunpowder, compresses hydrogen to about 10,000 times atmospheric pressure and fires a 100-gram projectile that can reach a maximum velocity of 6.5 km/s (14,500 mph)—about 20 times the speed of sound—before it hits the fusion target.

The gun will be used in parallel with First Light's Machine 3—an electromagnetic launch pulsed power machine—and will allow engineers to explore a different parameter space by launching larger but slower projectiles.

"Our fusion technology is driven by the impact of a projectile traveling at significant speed into a fusion target," said Nick Hawker, chief executive officer of First Light Fusion. "These targets trade pressure and size, amplifying the pressure from initial impact to final collapse of the fuel capsule, which is a small part of the whole target. This new gun will deliver lower pressure than Machine 3, so we will have to rely on designs that amplify more. The larger size means we can do this and still get good performance. With both facilities together we can make more than twice as much progress on the most important aspect of our technology, which is the target."

Research & Applications continues

SHINE executives, construction managers, and partners commemorate a construction milestone of the medical isotope production facility in March. (Photo: SHINE)

MEDICAL RADIOISOTOPES

SHINE picks a second production site as U.S. construction continues

SHINE Medical Technologies plans to locate a European medical isotope production facility in the municipality of Veendam, the Netherlands, after a yearlong search and a review of more than 50 proposals from sites across Europe. The company announced on May 20 that construction at the site—SHINE's second medical isotope facility—should begin in 2023 with commercial production starting in late 2025.

The European facility will focus initially on the production of molybdenum-99, the precursor of technetium-99m, a diagnostic medical radioisotope used to identify heart disease, cancer, and other conditions. When completed, the facility will be capable of producing double the European patient need for Mo-99, according to SHINE, and when combined with U.S. capacity, the company's total production will meet 70 percent of the global patient need.

■ The Nuclear Regulatory Commission has approved a request by SHINE Medical Technologies for an exemption from regulations on how commercial-grade equipment is defined, allowing the company to more easily procure components for the medical isotope production facility it is building in Janesville, Wis.

Specifically, the NRC has exempted SHINE from requirements in 10 CFR 21.3 for the definitions of "commercial-grade item," "basic component," "critical characteristic," "dedication," and "dedicating entity." In requesting the exemption, SHINE said that for facilities other than nuclear power plants, the definitions are "unnecessarily restrictive." The NRC issued the exemption on April 30 and published a notice in the May 14 *Federal Register*.

The NRC issued SHINE a construction permit for its production facility in 2016. The plant, which will produce Mo-99 and other neutron-produced isotopes, is expected to be the largest medical isotope production facility by capacity in the world. SHINE has said it expects to receive NRC approval for its operating license by October of this year and to begin operations in late 2022.

EnergySolutions picked to decommission Kewaunee power plant

Utah-based EnergySolutions has entered into a definitive agreement with Dominion Energy to acquire the closed Kewaunee nuclear power plant for prompt decommissioning. Located about 30 miles southeast of Green Bay, Wis., the single-unit, 574-MWe pressurized water reactor was shut down in May 2013 for financial reasons.

Dominion completed the transfer of Kewaunee's used fuel to dry storage in June 2017. The remaining decommissioning work, to be executed by EnergySolutions, will result in the complete dismantlement of the facility and the removal of all radioactive waste.

Beginning the plant's decommissioning now will accelerate its completion and allow the property to be considered for reuse ahead of Dominion's original decommissioning schedule, EnergySolutions said. Dominion initially selected the Nuclear Regulatory Commission's SAFSTOR method of decommissioning, with the reactor to be maintained in a safe and stable condition for up to 60 years before decommissioning is completed.

With the definitive agreement signed, EnergySolutions and Dominion will finalize the required regulatory filings and begin the application process with the NRC for the transfer of Kewaunee's licenses.

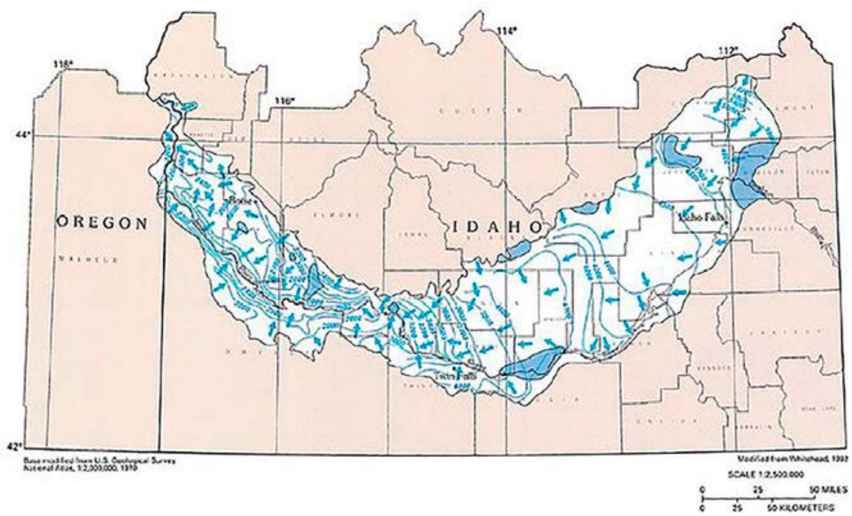
"We appreciate the confidence Dominion Energy has in our company by entering into this contract," said Ken Robuck, president and chief executive officer of EnergySolutions. "This project will fit nicely within our decommissioning project portfolio, and we are looking forward to applying our industry-leading decommissioning and waste management experience to this project."

EnergySolutions' other current decommissioning projects include the historic Three Mile Island-2 in Pennsylvania, the San Onofre Nuclear Generating Station in Southern California, and the Fort Calhoun nuclear power plant in Nebraska. EnergySolutions recently completed decommissioning work at the Zion nuclear plant in Illinois and the La Crosse boiling water reactor in Wisconsin.

Above: EnergySolutions will acquire Kewaunee for decommissioning. (Photo: Dominion Generation)

IDAHO SITE

Jacobs-led coalition awarded 10-year, $6.4 billion cleanup contract



The Snake River Plain Aquifer.

The Department of Energy's Office of Environmental Management will award the Idaho Cleanup Project (ICP) contract for the Idaho National Laboratory site to Idaho Environmental Coalition (IEC) of Tullahoma, Tenn. The contract has an estimated ceiling of approximately $6.4 billion over 10 years, with cost reimbursement and fixed-price task orders to define the contract performance.

Led by engineering company Jacobs as the majority partner, IEC takes over the work done by Fluor Idaho, which has held the site cleanup contract since 2016. The IEC team also includes Idaho Falls–based North Wind Portage and small business subcontractors Navarro Research and Engineering, Oak Ridge Technologies, and Spectra Tech.

The DOE said on May 27 that the procurement was awarded under a full and open competition, with five contract proposals submitted.

The work to be performed under the new ICP contract will include the following:

- Operations of the Integrated Waste Treatment Unit.
- Spent nuclear fuel management, including the Nuclear Regulatory Commission–licensed independent spent fuel storage installations at the INL site and Fort Saint Vrain, near Platteville, Colo.
- Transuranic and low-level radioactive waste disposition and management.
- Facility decontamination and decommissioning.
- Environmental remediation activities.
- Facility infrastructure.

According to the DOE, the cleanup contract will support approximately 1,900 jobs paying prevailing wages, with workers retaining the right to unionize and bargain collectively. Union-represented workers currently make up approximately 43 percent of the total workforce.

"Jacobs welcomes the opportunity to partner with the DOE to advance the restoration of the ICP to beneficial reuse for the INL and Idaho Falls community," said Karen Wiemelt, senior vice president of Jacobs Critical Mission Solutions, North American Nuclear. "Together with the DOE, Jacobs will use our technology-driven solutions to reduce the environmental legacy of the Cold War, support high-quality jobs in the region, and protect the Snake River Plain Aquifer, a critical element of Idaho's agricultural industry."

Waste Management continues

Disposal area closes

Work crews recently placed a final radioactive waste shipment into the Idaho National Laboratory site's largest waste disposal area. The Department of Energy's Office of Environmental Management noted on May 25 that it would begin closing the facility, fulfilling its commitment to the state of Idaho.

Workers from Fluor Idaho, the DOE's current INL site cleanup contractor, used a 55-ton cask to insert activated metals into a concrete-lined vault within a fenced section of the 97-acre disposal site, known as the Subsurface Disposal Area (SDA). The metals are structural components of nuclear fuel assemblies that have been removed from reactors. The metal end pieces from the fuel assemblies are detached and disposed of in one of the vaults at the site.

Work crews prepare to place the final waste shipment into a vault at the SDA at the INL site. (Photo: DOE)

The SDA began receiving INL-generated radioactive and hazardous waste in 1952. Beginning in 1954, the landfill accepted Cold War weapons waste from the former Rocky Flats Plant in Colorado and other off-site generators. Due to a policy change in 1970, the SDA stopped receiving transuranic and hazardous waste for disposal but continued to receive boxed low-level radioactive waste and, later, highly radioactive metal debris in specially designed vaults inside the SDA.

The DOE noted that the SDA is unique in that targeted waste is being removed under a federal regulation, while other waste, such as activated metals, has been disposed of in the landfill vaults under a separate federal regulation.

Following closure of the SDA, activated metals will be disposed of in a facility managed by INL contractor Battelle Energy Alliance. That disposal facility is located near the Advanced Test Reactor Complex in the central portion of the 890-square-mile INL site.

Canada's Pickering nuclear power plant. (Photo: OPG)

CANADA

Nuclear leaders to collaborate on CANDU D&D

A collaboration agreement signed by Ontario Power Generation's Center for Canadian Nuclear Sustainability, Canadian Nuclear Laboratories, and SNC-Lavalin will build on Ontario's extensive nuclear industry expertise and skilled workforce to support the decontamination and decommissioning of CANDU reactors in Canada and around the world, according to a May 13 press release from the organizations. The work will include the decommissioning of OPG's Pickering nuclear power plant following the end of commercial operations in 2025.

In addition to exploring the potential for international decommissioning opportunities, the collaboration is intended to drive best practices and innovation for delivering decommissioning projects in a safe, timely, and cost-effective manner. The organizations will also work to identify future workforce skill gaps and develop plans to fill any such gaps.

There are more than 30 Canadian-designed CANDU reactors around the world, including plants in Argentina, Romania, China, India, Pakistan, and South Korea.

According to OPG, the decommissioning of Pickering will be supported by SNC-Lavalin subsidiary Candu Energy, which has decommissioning experience in the United States and Canada. OPG said it will also leverage Canadian Nuclear Laboratories' expertise in decommissioning, packaging and storage, and environmental protection to safely dismantle and repurpose the Pickering site.

Located near Toronto on the north shore of Lake Ontario, Pickering houses six operating CANDU reactors with a total capacity of 3,094 MWe. Under OPG's proposed plan, Pickering Units 1 and 4 will be shut down in 2024, followed by Units 5 to 8 in 2025. Units 2 and 3 were shut down in 2007 and 2008, respectively.

"As the owner of the largest reactor fleet in Canada, OPG will play a leading role in providing sustainable solutions for decommissioning to benefit the environment, economy, community, and industry," said Carla Carmichael, vice president of OPG's decommissioning strategy and lead for the company's recently opened Center for Canadian Nuclear Sustainability. "The solutions we develop through this group will be applied not only in Pickering, post–commercial operations, but have the potential to be used internationally and create jobs and opportunities for Canada's nuclear industry at home and abroad."

Waste Management continues

A deposition tunnel is excavated into bedrock at Finland's Onkalo facility. (Photo: Posiva)

FINLAND

Excavation of first repository tunnels begins at Onkalo

Posiva Oy, the company responsible for the disposal of Finland's spent nuclear fuel, announced in May that it has begun excavating the first disposal tunnels at the Onkalo deep geologic repository near the Olkiluoto nuclear power plant. Posiva, which is owned by Finnish nuclear plant operators Fortum and Teollisuuden Voima, said that the start of construction is a significant milestone, as it comes after years of research and development activities on methodology for rock construction.

The Onkalo repository will be the first geologic disposal facility in the world for spent nuclear fuel when it begins disposal operations, expected in the mid-2020s. Initial construction work on Onkalo, which will be constructed at a depth of 400 to 430 meters (about 1,300 to 1,400 feet), began in 2004. The Finnish government granted Posiva a license for constructing the final disposal facility in 2015.

Posiva said that the first five tunnels, to be excavated during the next 18 months, mark the beginning of an extensive building effort. It is estimated that 100 deposition tunnels will be excavated during Onkalo's 100-year operational period, totaling a length of about 35 kilometers. The tunnels, which will have a maximum length of 350 meters, are about 4.5 meters high and about 3.5 meters wide.

Posiva has opted for final disposal based on the KBS-3V method developed by the Swedish nuclear fuel and waste management company SKB. The method involves placing spent fuel canisters in deposition holes drilled into the repository's disposal tunnels. The copper and steel canisters will be surrounded by a bentonite clay buffer within the deposition hole. Depending on how many deposition holes there are in a tunnel, which is determined by the volume of suitable rock based on the rock fractures, about 30 canisters will be placed in one tunnel, accommodating about 65 tons of spent nuclear fuel, Posiva said.

The encapsulation of spent fuel and the emplacement of the canisters in the deposition holes will start once the Finnish government grants an operating license for the facility.

In Case You Missed It—Waste Management

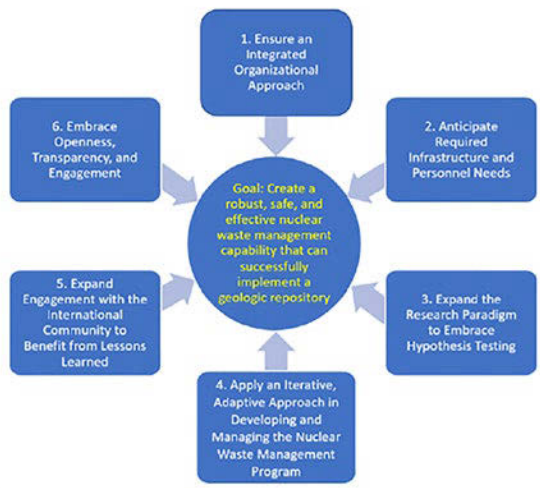
Secretary Granholm is being urged to form an office devoted to waste management within the Department of Energy. The American Nuclear Society joined seven other prominent nuclear organizations in submitting a letter to energy secretary Jennifer Granholm requesting that the DOE establish an office dedicated to developing and managing an integrated nuclear waste storage, transportation, and disposal program.

Granholm

"We urge you to take this action immediately, particularly given the funding recently provided by Congress under the Consolidated Appropriations Act of 2021," the letter states. The letter also asks that the new office report directly to the energy secretary.

Joining ANS executive director and chief executive officer Craig Piercy in signing the May 3 letter to Granholm were Maria Korsnick, president and CEO of the Nuclear Energy Institute; Bud Albright, president and CEO of the United States Nuclear Industry Council; Paul Kjellander, president of the National Association of Regulatory Commissioners; Katie Sieben, chair of the Nuclear Waste Strategy Coalition; Wayne Norton, steering committee chair for the Decommissioning Plant Coalition; Ron Woody, executive board chair of the Energy Communities Alliance; and Charles Fairhurst, member of the Science Panel of the Sustainable Fuel Cycle Task Force.

In hopes of spurring the U.S. nuclear waste program, the Nuclear Waste Technical Review Board (NWTRB) has released a report titled *Six Overarching Recommendations for How to Move the Nation's Nuclear Waste Management Program Forward*. According to the NWTRB, the report synthesizes the current board members' nearly decade-long experience reviewing numerous Department of Energy technical programs related to the management and disposal of spent nuclear fuel and high-level radioactive waste. The report, which was released on April 30, is also informed by the study of and a number of visits to programs and facilities in other countries, the NWTRB said.



The NWTRB was created by Congress to evaluate the technical and scientific validity of the Department of Energy's work related to the management and disposal of SNF and HLW. The report can be found on the NWTRB website, at nwtrb.gov.

For in-depth coverage of these stories and more, see ANS's Nuclear Newswire *at ans.org/news.*

ANS names Annual Meeting award winners, new Fellows

The American Nuclear Society has selected recipients for six awards that were presented during the 2021 ANS Virtual Annual Meeting, held June 14–16. The Society also named eight new Fellows, who were honored during the opening plenary session.

Henry DeWolf Smyth Nuclear Statesman Award

Kristine L. Svinicki, ANS member since 1988 and former chairman of the U.S. Nuclear Regulatory Commission, in recognition of three decades of leadership and service in meeting the clean energy needs of the global community.

Walter H. Zinn Medal

Jose N. Reyes Jr., ANS member since 1977 and cofounder and chief technical officer of NuScale Power, in recognition of revolutionizing 21st century nuclear power with the design of an innovative, passively cooled, NRC-licensed small modular reactor.

Leadership Award

Steven A. Arndt, ANS Fellow and member since 1981 and Distinguished Scientist at Oak Ridge National Laboratory, in recognition of his exemplary leadership and lifelong dedication to efforts that advanced a wide range of technical and policy initiatives that improved nuclear safety standards across the industry.

Harsh S. Desai, ANS member since 2005 and senior manager at the Nuclear Energy Institute, in recognition of his outstanding leadership and extraordinary contributions to the American Nuclear Society.

Landis Young Member Engineering Achievement Award

Nicholas R. Brown, ANS member since 2006 and an associate professor of nuclear engineering at the University of Tennessee–Knoxville, in recognition of his technical leadership in advancing the safety case for accident tolerant fuel and cladding and in paving the way for the licensing of advanced nuclear reactors.

Paul K. Romano, ANS member since 2005 and a computational scientist at Argonne National Laboratory, in recognition of his leadership in advancing the state of the art and breadth of the impact of computational nuclear engineering.

Mishima Award

Robin W. Grimes, professor at Imperial College London (U.K.), in recognition of his seminal contributions to the application of atomistic simulation techniques to predict governing phenomena in nuclear materials, including fuel performance and the radiation tolerance of ceramic waste forms.

Special Award

For making advanced nuclear energy systems a reality: going beyond promotion toward deployment

D. V. Rao, ANS member since 2015 and program director for civilian nuclear at Los Alamos National Laboratory, in recognition of advancing small reactor deployment opportunities by designing new space reactors, microreactors, and moderating materials for low-enriched uranium fuel.

Fellows

Bradley J. Adams, ANS member since 2009 and vice president of engineering at Southern Nuclear Operating Company, in recognition of his outstanding technical leadership in nuclear engineering and plant operations. His hard work and vision have produced significant contributions to both nuclear operations and construction. He has become a major industry leader in guiding and addressing the most critical issues facing the long-term health and success of the entire U.S. nuclear fleet.

William E. Burchill, ANS past president (2008–2009) and member since 1970 and retired head of the Department of Nuclear Engineering at Texas A&M University, in recognition of developing one of the earliest complete analyses of the thermal-hydraulic phenomena during the Three Mile Island-2 accident. He improved the models for nuclear power system performance and accident simulation. He upgraded probabilistic risk analysis tools and introduced significant improvements in the application of risk-informed licensing practices.

Mark B. Chadwick, ANS member since 2011 and deputy associate director of Los Alamos National Laboratory, in recognition of his leadership in the United States of nuclear cross section evaluations leading to improved simulation performance across the range of nuclear applications; renowned contributions to modeling of plutonium fission; international leadership in nuclear science and technology; and substantial and enduring individual technical contributions to the nuclear enterprise.

Stuart A. Maloy, ANS member since 1999 and a deputy group leader at Los Alamos National Laboratory, in recognition of his outstanding accomplishments and leadership in radiation materials science and engineering. His expertise in microstructural analysis and interpretation of atomic-scale defects on changes to macroscopic-scale properties of metals underpins the development of innovative materials needed for spallation neutron sources, advanced fission and fusion reactors, and other energy applications.

ANS News continues

Robert P. Martin, ANS member since 1990 and safety analysis methods lead at BWX Technologies, in recognition of his sustained and significant technical contributions to the state-of-the art research in modeling nuclear power plant behavior during design-basis and beyond-design-basis accident scenarios that made it possible to increase efficiencies and power levels at operating nuclear power plants.

Kathryn A. McCarthy, ANS member since 1988 and associate laboratory director of fusion and fission energy and science at Oak Ridge National Laboratory, in recognition of her outstanding leadership, both nationally and internationally, leading to the advancement of fission reactor systems and fusion technologies.

Todd S. Palmer, ANS member since 1993 and a professor of nuclear science and engineering at Oregon State University, in recognition of his sustained contributions to the advancement of methods and algorithms for computational radiation transport impacting critical software assets at the National Nuclear Security Administration and nuclear energy national laboratories, and their innovative application in the analysis of high-energy-density and reactor physics systems.

Monica C. Regalbuto, ANS member since 2003 and director of nuclear fuel cycle strategy at Idaho National Laboratory, in recognition of her exceptional contributions to the nuclear fuel cycle and nuclear waste management mission by developing and demonstrating innovative nuclear energy technologies that have significantly advanced the scientific, engineering, policy, and regulatory aspects of the nuclear enterprise.

Young Members Group puts spotlight on Sandia National Labs

For the latest installment of its webinar series, Spotlight on National Labs, the ANS Young Members Group focused on Sandia National Laboratories. The webinar, which took place on May 11, is available to view on demand at ans.org/webinars.

Moderated by Matthew Jasica of Argonne National Laboratory, the 90-minute webinar featured a host of presenters from Sandia, including director James Peery. "If you don't already work at a national lab, I would encourage you to consider a DOE lab in any future employment decisions," Peery said in his opening remarks. "We get to work with some of the best people, engineers, scientists, administrators, and professionals that the nation—and in some cases the world—can produce."

Peery went on to describe Sandia's primary mission as nuclear deterrence, which it performs in conjunction with the Los Alamos and Lawrence Livermore labs. He added that Sandia designs and manufactures the nonnuclear components for the U.S. nuclear stockpile. "At Sandia, we're responsible for making sure a nuclear weapon will work if directed by the president of the United States," Peery said. "But just as important, we make sure a nuclear weapon will *never* work unless given presidential authorization."

The webinar also included presentations by seven Sandia employees, beginning with Rebecca Ullrich, a corporate historian who provided a brief timeline of Sandia's more than 75 years of operation. That was followed by technical presentations from J. Charles Barbour, director of the Radiation and Electrical Science Center; Erik McIntyre, Weaponeer Professional Development Programs lead; David L. Luxat, manager, Severe Accident Modeling and Analysis; Evaristo J. "Tito" Bonano, senior manager, Nuclear Energy Fuel Cycle; and Doug Osborn, nuclear engineer, International Nuclear Security Engineering.

Caroline Winters, mechanical engineer, chair of Advancing the Next Generation of Leadership Excellence, concluded the prepared portion of the webinar with information about the work environment at Sandia.

Sandia grew out of America's World War II effort to develop the first atomic bombs. Today, keeping the U.S. nuclear stockpile safe, secure, and effective is a major part of Sandia's work as a multidisciplinary, national security engineering laboratory. Sandia's role has evolved to address additional threats facing our country.

Sandia National Laboratories. (Photo: SNL)

Sandia's science, technology, and engineering foundations enable it to carry out its unique mission. The laboratories' highly specialized research staff is at the forefront of innovation, collaborating with universities and companies and performing multidisciplinary science and engineering research programs with significant impact on U.S. security. Sandia's workforce of 14,500 has earned more than 7,000 advanced degrees.

Nominations now being accepted for 2021 ANS Winter Meeting awards

For more than 50 years, the ANS Honors and Awards Program has recognized outstanding achievements and meritorious service in the various fields served by our Society.

The recipients of the national awards listed at right will be honored on November 30 during the opening plenary of the ANS Winter Meeting. Honorees will be notified of their selection by October.

All members are encouraged to review the nomination requirements for these awards and consider nominating a qualified colleague. Many ANS awards are open to non-ANS members, and nominating colleagues who are not members is one way to foster new ANS relationships.

Award list

- E. Gail de Planque Medal
- Dwight D. Eisenhower Medal
- Distinguished Public Service Award
- Milton Levenson Distinguished Service Award
- Fellow of ANS
- Landis Public Communication and Education Award
- Nuclear Historic Landmark Award
- Mary Jane Oestmann Professional Women's Achievement Award
- Reactor Technology Award (awarded with the Atomic Energy Society of Japan)
- Seaborg Medal
- Social Responsibility in the Nuclear Community Award
- Alvin M. Weinberg Medal
- Young Member Excellence Award
- Young Members Advancement Award

ANS News continues

For the first time, ANS will be awarding the Social Responsibility in the Nuclear Community honor this year. The award recognizes an individual, group, or organization for outstanding efforts in social responsibility promoting diversity, equity, and inclusion or inclusive community building in the nuclear community. It comes with a plaque and a $1,000 monetary award.

More information on each award, including past award recipients and nomination forms, is available at www.ans.org/honors. There you'll also find information about awards administered by ANS's professional divisions. If you have questions about a specific award, please contact Hash Hashemian, chair of the Honors and Awards Committee, at honors@ans.org.

The deadline for submission of nominations for Winter Meeting awards is August 1. Because of the large number of nominations typically submitted, late nominations are not accepted.

New Members

The ANS members and student members listed below joined the Society in May 2021.

Ball, Erick J., Energy Research Inc.
Bickley, Abigail, Air Force Institute of Technology

Chang Díaz, Franklin, Ad Astra Rocket Company
Cofer, Walter, Radiation Control
Cook, Christopher B., Nuclear Regulatory Commission
Creedon, Madelyn R., Green Marble Group
Crichlow, Henry, NuclearSAFE Technologies

D'Aurelio, Robert C.

De La Torre Aguilar, Fernando, Autonomous University of Zacatecas (Mexico)

Fest, Otto P., OTEK
Fountain, Eliott J., UT–Battelle

Gautham, Smitha, Virginia Commonwealth University
Gylling, Björn, Gylling GeoSolutions

Huffman, Matthew D., Georgia Tech Research Institute

Jayakumar, Athira V., Virginia Commonwealth University
Johnson, Paul M., Jr., Teledyne Brown Engineering

Kane, Mackenzie V.
Kelley, Sean M., Kelley Consulting Group
Kelly, Samuel, Canadian Nuclear Laboratories

Leslie, Geoffrey, MDA (Canada)
Li, Jianbo

Manley, Michelle A., G.D. Barri & Associates
Manoharan, Archie, BWX Technologies
Matsumoto, Jun, GE Hitachi Nuclear Energy
Maxwell, Gon, Teledyne Brown Engineering
Mofrad, Amir M., University of South Carolina

Oda, Takuji, Seoul National University (South Korea)

Poneman, Daniel B., Centrus Energy

Robinson, Lindsay, Oklo

Sebastiani, Patrick J., Westinghouse Electric Company
Seo, Seokbin, University of Tennessee–Knoxville
Smith, Matthew, U.S. Navy
Spangenberg, Joel C., Defense Nuclear Facilities Safety Board

Volcensek, Tyler J., U.S. Navy

Wikman, Gabriel, Tech Data (Sweden)
Windows, Erik M., Fluor/Naval Nuclear Laboratory

Yamanaka, Masao, Nuclear Engineering Ltd. (Japan)

STUDENT MEMBERS

Ardrey Kell High School (Charlotte, N.C.)
Hickman, Henry

Balseiro Institute (Argentina)
Ruiz, Kevin S.

Embry-Riddle Aeronautical University
Fedele, Elijah C.

Excelsior College
Bitner, Toni
Branham, Alexander K.
Colton, Michael C.
Fraley, Craig E.
Garcia, Oliver R.
Greene, Ronald R.
Harnes, Mark D.
Kaiser, Kenneth W.
Key, Owen E.
Mack, Quinton R.
Page, Taylor A.
Poland, Michael B.
Rabe, David A.
Robbins, Mark S.

Federal University of Rio de Janeiro (Brazil)
Monteiro, Vinicius de Melo

Georgia Institute of Technology
Khanpour, Cameron

Korea Advanced Institute of Science and Technology (South Korea)
Wijaya, Steven

Mansoura University (Egypt)
Elashry, Mohamed

McMaster University (Canada)
Racette, Joshua

Missouri University of Science and Technology
Grzovic, Connor

Nagoya University (Japan)
Amano, Toranosuke
Oike, Hiroya

North Carolina State University
Alsafadi, Farah R. H.
Jugan, Alina

Ohio State University
Abdullatif, Firas B.

Oregon State University
Brackbill, Anneli
Clements, Kayla

Purdue University
Pantopoulou, Styliani

San Jose State University
Sethu, Meenu

Seoul National University (South Korea)
Kim, Dongyeon

Texas A&M University–Kingsville
Shafiq, Mohammad U.

Thomas Edison State College
Dodge, Daniel

United States Military Academy
Peek, Nathaniel E.
Price, Jeffrey S.

University of Bangui (Central African Republic)
Ngremale Herve, Ngremale

University of California–Berkeley
Aissi, Shereen
Payne, Daniel

University of Delaware
Fidlow, Henry

University of Idaho
Goettsche, Heinrik

University of Illinois–Urbana-Champaign
Schau, Mathew

University of Massachusetts–Lowell
Kennedy, Jack J.

University of Michigan
Brannigan, Terence T.
Elkolaly, Zaynab O.

University of Notre Dame
Pasmann, Samuel

University of Tennessee–Knoxville
Adebayo-Ige, Promise
Deakins, Ethan
Harris, Frederic G.
Miller, Madalynn

Utah State University
Gardiner, John A.

Virginia Commonwealth University
Deloglos, Christopher S.

Institution not provided
Adeniyi, Abiodun I.
Coca de Ayala, Bernal
Crowder, Sophia
Hahn, William
Maher, Bradley
Morham, Maclaine C.
Nye, Owen
Singh, Nanak
Troutman, Alexandria D.

ANS News continues

ANS awards nearly 80 scholarships for the 2021–2022 academic year

This year, the American Nuclear Society Scholarship Policy and Coordination Committee, the ANS divisions, and the ANS local sections have awarded 78 scholarships for the 2021–2022 academic year. The scholarships total $203,000 of support for students pursuing degrees in nuclear science and technology.

Supporting ANS scholarships

To help educate and train the next generation of the nuclear workforce, ANS encourages donations to the Society's numerous scholarship programs. A description of each scholarship and a convenient online donation form, which allows donors to designate their contributions to support specific awards, are accessible at www.ans.org/scholarships/.

The Society thanks all the donors who have generously supported our scholarship programs. Your generosity has allowed ANS to fund 50 percent of the students who applied for scholarships in the past year.

Scholarships Awarded

Washington Internships for Students of Engineering (WISE)

Zachary T. Deziel, NASA
Robert B. Renfrow, Lipscomb University

NEED scholarships

Nontraditional Student Scholarships
Teyen Widdicombe, University of Idaho

John and Muriel Landis Scholarships
Madison N. Allen, University of Tennessee–Knoxville
Madison N. Bushloper, University of Florida
Alexander S. Hauck, Rensselaer Polytechnic Institute
Miriam A. Kreher, Massachusetts Institute of Technology
Ryan P. McGuire, Virginia Commonwealth University
Gibson D. Prall, University of New Mexico
Sierra A. Tutwiler, Virginia Commonwealth University

Community college/trade school scholarships

Kent Hamlin Memorial Scholarship
Micheal J. Bircher, Columbia Basin College
Thomas C. Oberhausen, Lakeland Community College

Undergraduate scholarships

ANS Incoming Freshman scholarships
Tucker H. Bundy, Idabel High School (Okla.)
Sarah E. Cole, Mountain View High School (Idaho)
Rory M. Coll, Leonardtown High School (Md.)
Alexander T. Edwards, Bob Jones High School (Ala.)
Carly E. Evans, Walled Lake Northern High School (Mich.)
Jonathan Liu, Saint Joseph High School (Ind.)
Lane M. Scheel, Palmyra-Eagle High School (Wis.)
Michael Shiwbaran, Central Park East High School (N.Y.)
Jasmine C. Walker, Copley High School (Ohio)
Gabriel W. Watson, Anderson County High School (Tenn.)

ANS Undergraduate (Sophomore) scholarships
William A. Graham, North Carolina State University

ANS Undergraduate (Junior/Senior) scholarships
Christian A. Arguello, University of New Mexico
Hayden S. Bland, North Carolina State University
Anthony G. Bowers, University of Massachusetts–Lowell
Grayson S. Gall, North Carolina State University
Jacob M. Halpern, Purdue University
Tyler J. Lewis, Purdue University
Charles McSwain, University of Tennessee–Knoxville
Robert H. Mendleski, Texas A&M University
Mitchell L. Mika, University of Florida
Kogan L. Powell, Utah State University
Anthony F. Tom, University of Tennessee–Knoxville

Angelo F. Bisesti Memorial Scholarship
Noah M. Higgins, North Carolina State University

Raymond DiSalvo Memorial Scholarship
Alisa K. Machiwalla, Kennesaw State University

William R. & Mila Kimel Nuclear Engineering Scholarship
Jack W. Fletcher, Missouri University of Science and Technology
Laura J. Shi, University of California–Berkeley

John R. Lamarsh Memorial Scholarship
Kaylee M. Cunningham, University of Florida
Abigail M. Davis, North Carolina State University

Hans P. Loewen Memorial Scholarship
Sophia L. Morton, Oregon State University

Accelerator Applications Division Scholarship
Noah M. Higgins, North Carolina State University

Operations and Power Division Scholarship
Benjamin M. McNeely, University of Massachusetts–Lowell
Katy J. Worrell, University of Tennessee–Knoxville

Fusion Energy Division Dr. Kenneth R. Schultz Undergraduate Scholarship
Joshua M. Hoffman, University of Illinois–Urbana-Champaign
Broderick M. Sieh, Kansas State University (honorable mention)

Rudi Stamm'ler Reactor Physics Division Scholarship
Timothy M. Kiefer, North Carolina State University

Graduate scholarships

ANS Graduate scholarships
Eli J. Boland, Missouri University of Science and Technology

Adam Darr, Purdue University
Ahmed Moustafa, North Carolina State University
Kathryn A. Mummah, University of Wisconsin–Madison
Rittu S. Raju, University of Michigan
Ashley R. Raster, Missouri University of Science and Technology
Ghada Shkoukani Alqous, North Carolina State University
Sarah R. Stevenson, University of California–Berkeley
Samuel O. Webster, North Carolina State University
Paige K. Witter, Colorado State University

Everitt P. Blizard Memorial Scholarship
Madeline L. Lockhart, North Carolina State University

Robert A. Dannels Memorial Scholarship
Emily H. Vu, University of Michigan–Ann Arbor

Decommissioning & Environmental Sciences Division Graduate Scholarship
Abdulsalam I. Shakhatreh, Virginia Tech

Ely M. Gelbard Graduate Scholarship
Hadyn Kistle, Texas A&M University

Alan F. Henry/Paul A. Greebler Memorial Scholarship
William C. Dawn, North Carolina State University
Gavin K. Ridley, Massachusetts Institute of Technology

Lawrence E. Hochreiter Graduate Scholarship
Adam Kraus, Pennsylvania State University

Saul Levine Memorial Scholarship
Katelyn C. Cook, Rensselaer Polytechnic Institute

Michael J. Lineberry Graduate Scholarship
Kaelee A. Novich, Boise State University

Nuclear Criticality Safety Pioneers Scholarship
Kristin N. Stolte, Texas A&M University

Fuel Cycle & Waste Management Division John D. Randall Scholarship
Hannah K. Patenaude, University of Nevada–Las Vegas

James F. Schumar Scholarship
Lorenzo Vergari, University of California–Berkeley

Robert E. Uhrig Graduate Scholarship
Vincent P. Paglioni, University of Maryland

Vogt Radiochemistry Scholarship
Madison N. Allen, University of Tennessee–Knoxville

Local section scholarships

ANS Oak Ridge/Knoxville Local Section Graduate Scholarship
Madison S. Ratner, University of Tennessee–Knoxville

ANS Oak Ridge/Knoxville Local Section Undergraduate Scholarship
Madison N. Allen, University of Tennessee–Knoxville

ANS Pittsburgh Local Section Graduate Scholarship
Miriam A. Kreher, Massachusetts Institute of Technology

ANS Pittsburgh Local Section Undergraduate Scholarship
Veronica Heyl, North Carolina State University

Washington, D.C., Local Section George P. Shultz and James W. Behrens Graduate Scholarship
Arturo Cabral, Virginia Commonwealth University
William Searight, Pennsylvania State University

Washington, D.C., Local Section Jeffrey A. Gorman Undergraduate Scholarship
Joshua M. Hoffman, University of Illinois–Urbana-Champaign

Bernice Paige: Everyone knew who she was

By Paul Menser

When it comes to women in nuclear research, one thinks of giants like Marie Curie and Lise Meitner. But when it came time for the American Nuclear Society to recognize one of its own, the first to receive the ANS Women's Achievement Award, in 1991, was Bernice Paige, a longtime chemist at the Atomic Energy Commission's Idaho Chemical Processing Plant. (Since 2001 the honor has been known as the Mary Jane Oestmann Professional Women's Achievement Award.)

Paige's contributions to what is now Idaho National Laboratory are substantial. From when she arrived in 1952 until she retired in 1981, she left her name on more than 100 publications and two patents pertaining to the chemical dissolution of nuclear fuel materials and emulsion control in liquid-suspension extraction.

At a time when few women worked at the National Reactor Testing Station, as the Idaho National Laboratory site was initially called, she was a big personality. "She was gregarious and outspoken—you mostly just listened," said Phil Anderson, who first became associated with Paige in the mid-1960s through the ANS Idaho Section and worked for her from 1976 to 1981 at the "Chem Plant" (now the Idaho Nuclear Technology and Engineering Center).

"When we had an 'Idaho reunion' at an ANS conference around 1990, we came up with some different categories to help people reminisce," Anderson said. "One of them was just one word: 'Bernice.' "

Radiochemist Bernice Paige in the spectroscopy lab of the Idaho Chemical Processing Plant in the 1950s.

Paige joined ANS in 1974 and presented numerous papers at conferences. As a volunteer, she chaired the ANS Public Information Committee and later the ANS Local Sections Committee, in addition to serving in most leadership positions of the ANS Idaho Section. When she received the Women's Achievement Award in 1991, her citation read, "For lifetime achievements in the chemistry of nuclear fuel reprocessing and high-level waste management and for pioneering work in underground corrosion evaluation and control."

Paige died in 2013 at the age of 89, leaving behind a legacy of work in chemical technology that included nuclear fuel dissolutions, chemical separations, high-level waste stabilization, and corrosion performance evaluation and control with structural materials.

In addition to her accomplishments in science, Paige was a world traveler and adventurer. With her husband, David, also a chemist and engineer, she set foot on all seven continents and visited the Himalayas repeatedly, to trek and work on projects organized by Sir Edmund Hillary.

A native of Iowa, she knew she was bound for college. "I was planning to attend Iowa State no matter what," she told the school's alumni magazine in 2001. She had $25 in her pocket and a job at the dime store when dairyman Clifford Stephens (for whom Iowa State's Stephens Auditorium was later named) was impressed enough with her to give her a scholarship. The $50 she received each quarter helped pay for tuition and some books.

After receiving her bachelor's degree in chemical technology in 1946, she started looking for a job. "I had companies tell me, 'We'd love to hire you, but we don't even have a women's restroom,'" she said. "I wanted to say, 'I don't care.'" Finally, during an interview in Buffalo, N.Y., E. I. du Pont de Nemours and Company offered her a job on the spot. "For a woman in the industry, that was very unusual," she said.

Paige and her husband worked for DuPont in New York and Delaware and later for the AEC at Oak Ridge, Tenn., and Savannah River, S.C. From there, they were recruited by Phillips Petroleum to come to Idaho.

Over 35 years, between 1953 and 1988, chemists and engineers at the Chem Plant separated and reprocessed spent reactor fuel, recovering 31,432 kilograms of uranium, as well as radioactive lanthanum, neptunium, krypton, and xenon, for use in private industry or at other nuclear operations.

"She had so much to say about so many things, some people might have thought she was flighty," Anderson said. "But her focus was intense. We were all aware of it. Everybody knew who she was."

"I can say from firsthand experience that she was a woman of great integrity and vision," said Bryan Parker, whom Paige hired in 1980 to work in the Chem Plant's analytical labs. "She was really smart, but never came across as too smart." Now a senior development consultant for INL, Parker credits Paige's mentoring as being life changing. "I remember she told me once—and I haven't forgotten this in 38 years—'Find the path that makes you happy and stay on that path.'"

In 1960, Paige filed for her first patent, titled "Emulsion control in liquid-suspension extraction," in which she and her colleagues Kenneth Rohde and Bill Newby offered an improved solvent-based process for extracting plutonium-239 and uranium-233 from spent nuclear reactor fuel.

United States Patent [19] [11] **3,965,237**
Paige [45] **June 22, 1976**

[54] **DISSOLUTION PROCESS FOR ZrO_2-UO_2-CaO Fuels**

[75] Inventor: **Bernice E. Paige,** Idaho Falls, Idaho

[73] Assignee: **The United States of America as repesented by the United States Energy Research and Development Administration,** Washington, D.C.

[22] Filed: **Apr. 11, 1975**

[21] Appl. No.: **567,216**

[52] **U.S. Cl.** .... **423/4;** 252/301.1 R; 423/20
[51] **Int. Cl.²** **C01G 43/02**
[58] **Field of Search** .... 423/4, 20; 252/301.1 R

[56] **References Cited**

UNITED STATES PATENTS

3,341,304 9/1967 Newby 423/4
3,813,464 5/1974 Ayers .... 252/301.1 R

OTHER PUBLICATIONS

Combustion Engineering, Inc., *Nucl. Sci. Abstr.*, 22, No. 41086, (Oct. 1968).
Bower et al., *Nucl. Sci. Abstr.*, 24, No. 22739, (June 1970).

Primary Examiner—Edward A. Miller
Attorney, Agent, or Firm—Dean E. Carlson; Arthur A. Churm; Robert J. Fisher

[57] **ABSTRACT**

The present invention provides an improved dissolution process for ZrO_2-UO_2-CaO-type pressurized water reactor fuels. The zirconium cladding is dissolved with hydrofluoric acid, immersing the ZrO_2-UO_2-CaO fuel wafers in the resulting zirconium-dissolver-product in the dissolver vessel, and nitric acid is added to the dissolver vessel to facilitate dissolution of the uranium from the ZrO_2-UO_2-CaO fuel wafers.

7 Claims, No Drawings

Paige's patent from 1976 for an improved dissolution process for ZrO_2-UO_2-CaO PWR fuels.

"The recovery of such values is, of course, an economic necessity," they wrote. "No reactor now known is able to consume in a single run the fissionable fuel with which it is charged to anywhere near completion, and therefore the unconsumed portion must be recovered if the costs of reactor operation are not to become excessive."

History continues

Her second patent, which she authored herself in 1976, involved another difficult chemical separation—dissolving uranium oxide, zirconium dioxide, and calcium oxide wafers used in pressurized water reactor fuel.

Anderson remembers that when he first met Paige in the 1960s, there were probably only about five women working at the Idaho AEC site as chemists, physicists, and radiologists. "There weren't many, and they weren't paid as well as men doing the same work," he said. In fact, when the first effort to level up salaries finally came in the 1970s, Paige told him she'd never imagined getting such a hefty raise.

Married for 61 years, Bernice and David (who died in 2010) were dedicated hikers and backpackers. They were founding members of the Idaho Trails Council and members of the Lewis and Clark Trail Foundation and the Continental Divide Trail Alliance. In Nepal, they helped endow an elementary school and medical clinic for the children of their Sherpa friends.

"They were fantastic people," said Lex Hightower, an INL employee who grew up next door to the Paiges, who had no children of their own. "They always brought me back some little pottery item or a type of customary clothing from Nepal. With those two as neighbors and friends, my science projects were always crazy cool!"

Paige never forgot the help she received to get her through school. In 2001, she and her husband established the Bernice E. Paige Scholarship in Chemical and Biological Engineering at Iowa State for female students.

"I had to work a lot while I was taking classes, and I know how hard it is," she said. "This scholarship will go to kids who can't make it all the way on their own. . . . I wouldn't have anything if someone hadn't helped me get my degree."

Paul Menser is a general assignment writer for INL Communications and Outreach.

15 years and going strong—Texas A&M University's NSSPI

By Kelley Ragusa

The Center for Nuclear Security Science and Policy Initiatives (NSSPI), a joint center of Texas A&M University and the Texas A&M Engineering Experiment Station, is celebrating its 15th anniversary this year. NSSPI contributes to the pipeline of nuclear security professionals through its educational, research, and workforce development activities that focus on nuclear security science and interface with national and international policy.

When asked where NSSPI stands after 15 years, current NSSPI director Sunil Chirayath said, "NSSPI has become a brand, and with that brand comes benefits, but also responsibility." At every step of its development, NSSPI has expanded its activities and scope to serve students, other universities, national laboratories, international organizations, U.S. government agencies, and industry. This has created a strong, sustainable academic group at Texas A&M, with links to all these stakeholders.

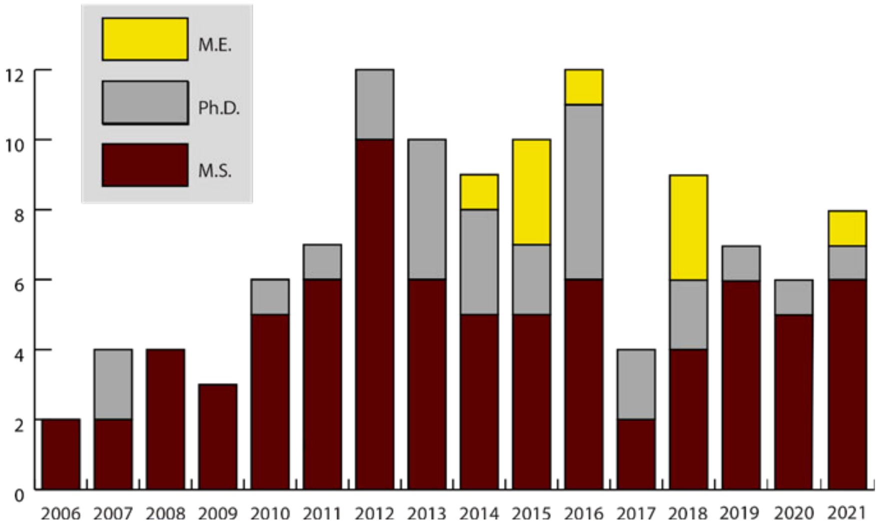
NSSPI's founding

The vision of William S. Charlton, Kenneth L. Peddicord, and Warren F. Miller Jr. led to the creation of NSSPI as a collaborative effort between the university's Department of Nuclear Engineering and the Bush School of Government and Public Service. In 2004, Charlton, NSSPI's founding director, spearheaded the addition of a nuclear nonproliferation specialization track to the nuclear engineering master's degree program, the first technical nuclear nonproliferation–focused master's degree of its type in the United States. This newly created nonproliferation education and research track was further developed and nurtured by NSSPI beginning in March 2006. The degree required students to take core and nonproliferation specialization courses in nuclear engineering while also participating in international affairs courses offered by the Bush School.

The political and social science disciplines in academia already had programs focused on nuclear nonproliferation and nuclear security policy that pre-dated NSSPI's formation. To complement these policy-centered programs, NSSPI focused primarily on a technical orientation in the nuclear security sciences with policy as a supporting element to help students understand the policy implications of new, sensitive technologies based on nuclear science and engineering.

In addition to offering nuclear security and nonproliferation courses, NSSPI has performed innovative technical research with the involvement of students interested in the study of nuclear security, safeguards, and nonproliferation. NSSPI conducted collaborative research and development, starting

Education continues



Degrees conferred on NSSPI students, by year. (Graphic: NSSPI)

with Los Alamos National Laboratory and subsequently with other national laboratories, which allowed students to respond directly to real-life engineering problems being studied in nuclear security and nonproliferation. Through these collaborations, Texas A&M provided a critical service of feeding the pipeline with work-ready graduates in this area to the national laboratories.

According to Miller, former assistant secretary for nuclear energy in the Department of Energy and currently a professor of the practice in the Texas A&M Department of Nuclear Engineering, "The vision of creating NSSPI was to provide to the nation a vehicle through which the multidisciplinary research, teaching, and service capabilities of a major university could be focused on the range of issues related to nuclear security. From the beginning, the intent was to bring relevant engineering, science, and policy capabilities that exist and could be developed at Texas A&M to make major contributions in this arena."

With the help of U.S. Rep. Chet Edwards, NSSPI obtained seed funding of about $2 million per year for three years from the DOE's National Nuclear Security Administration (NNSA) to realize its vision. Over the past 15 years, NSSPI has received resources from federal agencies, industry, and national laboratories for continuing and enhancing their multidisciplinary research, education, and workforce development programs in nuclear security and nonproliferation by utilizing the full capabilities of the university. NSSPI's average annual research expenditure for the past 15 years has been $2.38 million, out of which $1.54 million per year was utilized for multidisciplinary research.

"When we formed NSSPI in 2006," Charlton said, "we had no idea that it would grow as rapidly and successfully as it did. There was a clear need for an increased focus on nuclear nonproliferation research and education, and the importance of that focus is still strong today. The key differentiating capability of NSSPI was the linkage between nuclear engineering and international affairs. That focus on the development of NSSPI students continued long after I stepped down as director in 2015, and it still continues today."

Within three years, NSSPI had grown to include faculty members David Boyle (nuclear weapons test monitoring), Paul Nelson (transport theory, computational methods), Sunil Chirayath (nuclear fuel cycle, safeguards approaches development, nuclear forensics, Monte Carlo radiation transport simulations), and Craig Marianno (nuclear instrumentation development, physical protection system design, radiological consequence management), each of whom brought their unique expertise to the center and expanded the scope of NSSPI's education and research capabilities. In that period, NSSPI also added professional staff members Claudio Gariazzo, Kelley Ragusa, Lana Wilson, and Gayle Rodgers to support its mission.

NSSPI graduate Braden Goddard, who is currently an assistant professor at Virginia Commonwealth University, said, "Before NSSPI was created, it was uncommon to find any academic courses or professors focused on nonproliferation and nuclear security. These programs were mostly in political science and mainly consisted of one course and one professor. NSSPI created a critical mass of faculty and courses on these topics and included the science and technical approaches used in solving these challenges."

The 2019 International Nuclear Facilities Experience took students and early career professionals from the national laboratories to various sites in Europe. (Photo: NSSPI)

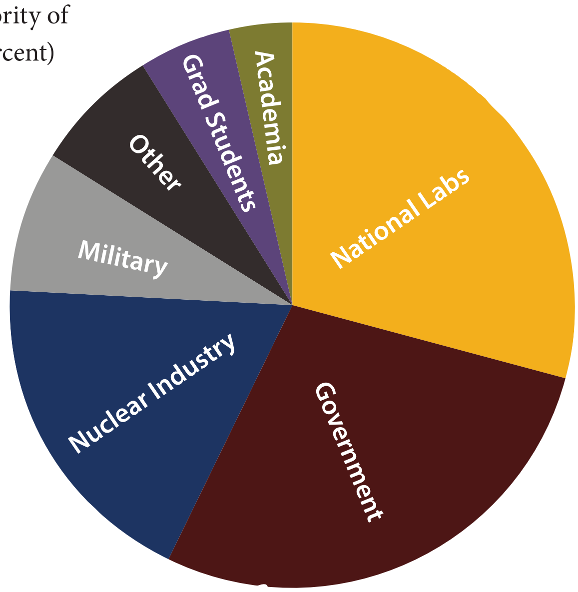
A well-rounded education

The nonproliferation specialization master's degree provided an academic underpinning to the education of the students involved with NSSPI. In addition to classroom education, experiences for students include annual trips to national laboratories, participation in hands-on safeguards training sessions and other training opportunities, and student exchanges that give them opportunities to travel internationally and expand their networks.

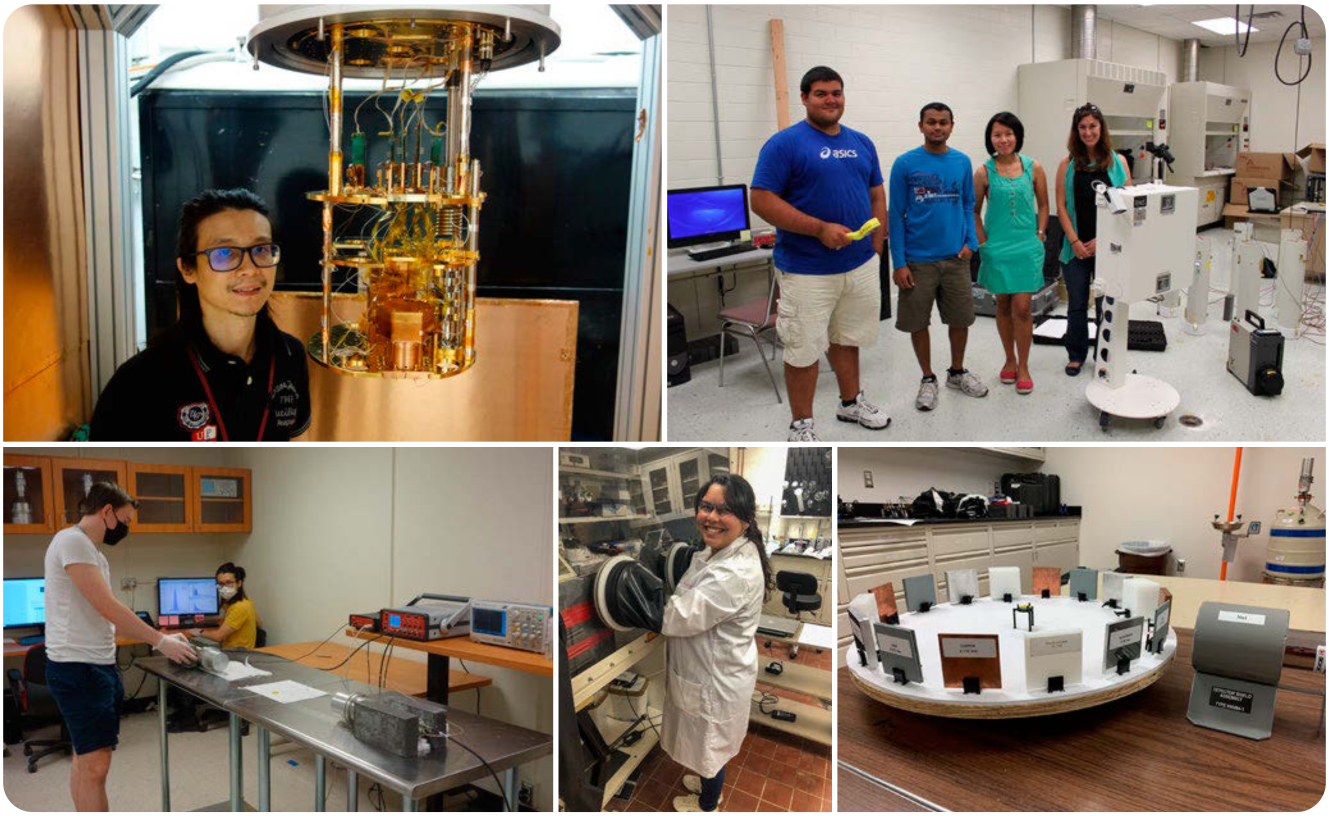
The International Nuclear Facilities Experience (INFE), organized by NSSPI and Argonne National Laboratory and sponsored by the NNSA, allows NSSPI students to join with nuclear security and nonproliferation students from other U.S. universities and early career professionals from national labs to tour nuclear fuel cycle facilities in foreign countries. Past INFEs have taken students to Japan, the United Kingdom, and continental Europe. NSSPI also organizes Domestic Nuclear Facilities Experiences to tour nuclear facilities and national labs in Texas and New Mexico.

In 2005, Texas A&M became the first university to host a student chapter of the Institute for Nuclear Materials Management (INMM), with Charlton as the first faculty advisor. The INMM student chapter sponsors seminars, workshops, and social events for Texas A&M students interested in nuclear nonproliferation. In coordination with NSSPI faculty members and professional staff, it also promotes participation in the larger professional society and has inspired the establishment of more student chapters at universities in the United States and around the world.

Since its inception in 2006, NSSPI has produced 105 graduates specializing in nuclear security and nonproliferation research (see chart at right). The majority of NSSPI graduates (54 percent) go on to careers in government or the national laboratories. Other destinations for NSSPI graduates include the nuclear industry (20 percent), the military (8.6 percent), academia (3.8 percent), and the International Atomic Energy Agency (2 percent).



Education continues

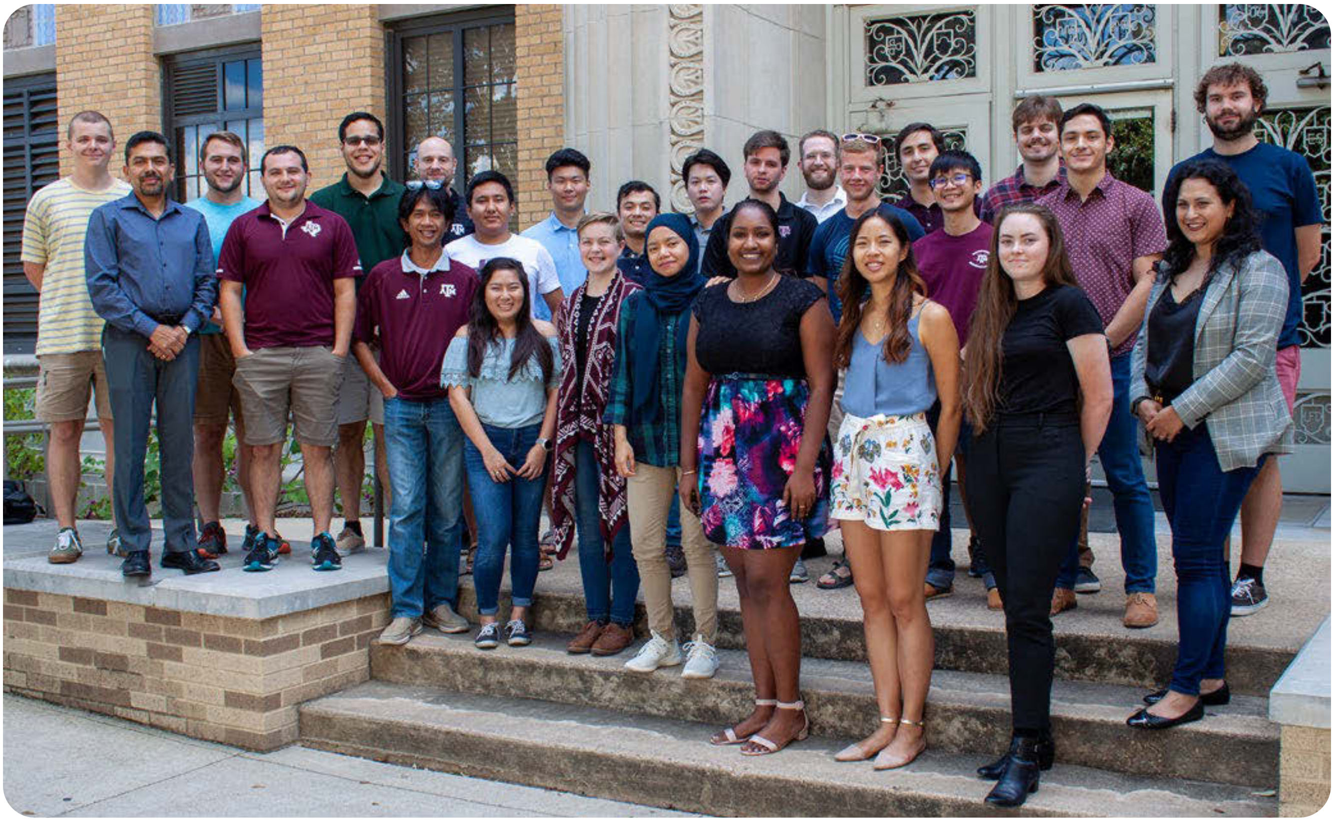


NSSPI facilities, clockwise from top left: antineutrino detection setup at the Texas A&M University research reactor; the Nuclear Security and Emergency Response Laboratory; the Remote Detection Laboratory used for remote classroom experiments; the Nuclear Forensics and Radiochemistry Laboratory; and the Neutron Sensing Laboratory. (Photos: NSSPI)

Experiential education

Research undertaken by NSSPI faculty and students supports two of its missions: (1) to conduct policy-informed technical research in collaboration with national labs and other partners to develop and apply science and technology to detect, prevent, and reverse the proliferation of nuclear and radiological weapons; and (2) to educate the next generation of leaders in the field of nuclear security and nonproliferation. To meet these twin missions, NSSPI used its NNSA seed funding, as well as resources from other research projects sponsored by various federal agencies, including the Department of Homeland Security and the Department of Defense, to develop experimental labs at Texas A&M with the equipment needed to conduct research in focus areas. The research facilities under NSSPI's purview include the Nuclear Forensics and Radiochemistry Laboratory, the Nuclear Security and Emergency Response Laboratory, the Radiation Detection and Measurements Laboratory, and the Neutron Sensing Laboratory.

Some of NSSPI's key research projects have focused on nuclear safeguards instrumentation, nuclear forensics methods, neutron detector design, radiation detector simulation, proliferation pathways analysis, plutonium source attribution, advanced reactor safeguards, nuclear weapons latency, advanced safeguards measurement techniques, border monitoring methods to prevent nuclear material smuggling, antineutrino measurements, and consequence management. Most of NSSPI's research endeavors are policy-informed through collaboration with the Bush School and the Texas A&M Department of Political Science. Research partners include relevant federal agencies, national labs, the IAEA, universities, and nongovernmental organizations.



Group photo of NSSPI faculty and students taken in fall of 2019. (Photo: NSSPI)

Serving the world

As part of its mission to serve as a public resource for knowledge and skills to reduce nuclear threats, NSSPI partners with countries and organizations around the world to help develop safeguards capabilities and enhance the global nuclear security culture. NSSPI faculty frequently present lecture series and workshops at universities in other countries and serve as experts for IAEA training activities. Some of the countries that have benefited from NSSPI-led training include Brazil, the Czech Republic, Ghana, India, Indonesia, Japan, Jordan, Kenya, Malaysia, Nigeria, South Africa, Thailand, Ukraine, and the United Arab Emirates.

NSSPI also conducts asynchronous online training through its Nuclear Security and Safeguards Education Portal (NSSEP) to disseminate knowledge in nuclear and radiological sciences, security, and safeguards to professionals and students across the globe. Developed with support from the NNSA and the State Department's Office of Cooperative Threat Reduction, this resource has the capacity to reach an audience greater than is possible through face-to-face training. In fiscal year 2020, NSSEP delivered more than 1,400 courses to 500 registrants.

During the COVID-19 pandemic, NSSEP courses were promoted extensively by the U.S. national laboratory complex as suitable training for lab employees to complete while working from home. NSSEP modules have also been the basis for two professional certificates offered by the Texas A&M Engineering Experiment Station, as well as the "Policy and Technical Fundamentals of International Nuclear Safeguards Workshop," held on the sidelines of the INMM's 2018 and 2020 annual meetings, with a third workshop to be conducted this summer.

NSSPI today

Today, NSSPI supports approximately 30 graduate students and a few undergraduate students at any given time to study and conduct research in the nuclear security and nonproliferation field. In addition to Chirayath, NSSPI's core faculty consists of its deputy director, Craig Marianno, and faculty fellows Shaheen Dewji and Shikha Prasad. Professional staff members Oscar Acuna and Kelley Ragusa lead training

Education continues

and outreach efforts. NSSPI has kept its core faculty and staff to a minimum and draws from intradepartmental and intrauniversity researchers based on the type of multidisciplinary research at hand.

In acknowledging the continued success of the NSSPI program, Michael Nastasi, the current head of the Department of Nuclear Engineering at Texas A&M, commented, “NSSPI, one of the largest graduate student research groups in the department, fosters excellence in research and education in the nuclear security and nonproliferation areas. Its efforts over the past 15 years have established it as a leader in its field, making it a very valuable asset to the Department of Nuclear Engineering.”

Given the global expansion of nuclear energy, with growing interest in advanced reactor technologies, NSSPI looks to play a role in supporting technical education, research, and workforce development to safeguard nuclear materials and reduce nuclear threats in response to a changing landscape. As it has in the past, NSSPI will evolve to provide the best possible education to its students to prepare them to take on leadership roles in the future.

Kelley Ragusa is an instructional designer at NNSPI.

Note: Nuclear News *publishes news about nuclear industry contracts—but only about contract awards. We generally do not publish announcements that the work is underway or announcements that the work has been completed. Email your new contract award announcements to nucnews@ans.org.*

BUSINESS DEVELOPMENTS

Bloom Energy, INL to generate hydrogen powered by nuclear energy

Bloom Energy has announced an agreement with **Idaho National Laboratory** to independently test the use of nuclear energy to create clean hydrogen through Bloom Energy's solid oxide, high-temperature electrolyzer. This carbon-free hydrogen is obtained through electrolysis that is powered by nuclear generation. INL will test Bloom Energy's electrolyzers at the Dynamic Energy Testing and Integration Laboratory in Idaho, where researchers can simulate steam and load-following conditions as if electrolyzers were already integrated with a nuclear power station.

■ **Framatome** was selected by the French **Alternative Energies and Atomic Energy Commission** (CEA) to provide a critical test system for the Jules Horowitz Research Reactor in Cadarache, France. To support qualification of the JHR, Framatome will build a customized test loop to investigate and characterize the flow-induced vibration behavior of internal reactor components. Framatome experts will design, build, deliver, and commission the test loop at the company's Le Creusot site in Burgundy and perform the qualification tests required for the licensing file of the JHR. Framatome's test loop is expected to start component testing in the fourth quarter of 2021.

Framatome also announced it was selected by the **European Laboratory for Particle Physics** (CERN) to perform postirradiation examinations of refractory materials irradiated with high-energy proton beams. CERN will provide Framatome with six radioactive target blocks irradiated in the prototype. Framatome experts will complete specialty testing and measurement studies to assess microstructural, mechanical, and thermophysical characteristics of the targets.

■ **GE Hitachi Nuclear Energy** and **GE Digital** have announced the introduction of Outage Planning and Analytics, a digital solution to help nuclear power plant operators plan, schedule, and execute maintenance and refueling outages. The application was developed by GEH and GE Digital to help plant operators evaluate schedule status, track activities, estimate impacts, and improve decision making.

■ **Deep Isolation**, a specialist in spent nuclear fuel and high-level nuclear waste storage and disposal solutions, has signed a cooperative agreement with **Dominion Engineering Inc.**, which specializes in nuclear fuel services and technology with a focus on inspection and maintenance equipment designed for safety and integrity of nuclear fuel during operation and long-term storage. Deep Isolation and DEI will cooperate in the sales, development, and deployment of Deep Isolation's patented SNF and HLW disposal technology, with an initial focus on Latin America and an option to expand to other markets.

CONTRACTS

Jacobs selected for U.K. NDA asset management

The **Nuclear Decommissioning Authority**, the public body in charge of cleaning up legacy nuclear facilities in the United Kingdom, has selected **Jacobs** to provide asset management solutions. Under the four-year contract, Jacobs and its strategic supplier, **PA Consulting**, will support the NDA on the implementation of its asset management strategy, applying new digital decision-making tools to improve efficiency and reduce

Industry continues

operational costs on nuclear-licensed sites in the NDA estate.

■ **Framatome** recently signed two contracts to upgrade systems and equipment used to manage operations at the Krško plant in Slovenia. The company will design, deliver, and install new instrumentation and control systems and replace the thimble tubes, which are an important part of the plant's in-core neutron flux measurement system. The company will complete these upgrades during the plant's outage in autumn 2022.

ADVANCED REACTOR MARKETPLACE

NuScale, Prodigy sign MOU for a marine-deployed nuclear generating station

NuScale Power and **Prodigy Clean Energy**, a Canadian company that designs and develops marine nuclear plants, announced on May 14 a second memorandum of understanding to support business development opportunities for a marine-deployed nuclear generating station powered by the NuScale small modular reactor. NuScale and Prodigy have been collaborating since 2018, investigating the feasibility of integrating NuScale power modules into Prodigy's marine power station. The two companies have completed the conceptual design and economic assessment phases.

Earlier in May, NuScale announced it has retained **Guggenheim Securities**, a financial advisory and capital markets firm, to explore financing options to accelerate the commercialization of the company's SMR technology.

■ **Lightbridge**, an advanced nuclear fuel technology company, announced on May 11 that it has successfully demonstrated the manufacturing process for three-lobe, six-foot rods using surrogate materials. The six-foot length of the surrogate rods is the typical length of the fuel rods used by many small modular reactors now in development and licensing. Future fabrication of high-assay low-enriched uranium rodlets for loop irradiation testing in the Advanced Test Reactor, and ultimately commercial-length HALEU fuel rods, will use similar extrusion and casting techniques.

■ **QuesTek Innovations** has announced that it was awarded $1.1 million in Small Business Innovation Research Phase II funding from the Department of Energy. The funding will be used to design, develop, and qualify a novel materials solution and process for next-generation molten salt reactors. This new Phase II project will focus on efficient and cost-effective cold spray processing of bimetallic structures, with refractory-based alloys (e.g., molybdenum) as a surface layer to provide corrosion resistance and high-temperature stability on the surface of ASME-certified structural materials.

■ **Hatch** and **Terrestrial Energy** have signed an engineering services contract to support deployment of the Integral Molten Salt Reactor, a Generation IV nuclear power plant. The scope of the agreement includes support for engineering, component procurement, project and construction management, and power plant cost estimation relating to the development and construction of an IMSR power plant. Services will be provided by a team of Hatch engineers based in Ontario.

Standard on containment system leakage testing requirements updated

The American Nuclear Society has just published ANSI/ANS-56.8-2020, *Containment System Leakage Testing Requirements*. Initially issued in 1972 as N45.4, the 2020 revision marks the sixth edition of the standard. Over the years, there have been many changes in testing procedures due to advancements in computer and instrument technology.

Approved on December 11, 2020, ANSI/ANS-56.8-2020 specifies acceptable primary containment leakage rate test requirements to ensure valid testing. Its scope includes the following:

1. Leakage test requirements.
2. Test instrumentation.
3. Test procedures.
4. Test methods.
5. Acceptance criteria.
6. Data analysis.
7. Inspection and recording of test results.
8. Guidance on which components and pathways require testing.
9. Test frequency.

This standard provides a basis for determining leakage rates through the primary containment of light water reactor nuclear power plants and for the implementation of an acceptable leakage testing program. It also provides a basis for determining which containment barriers require leakage testing.

The previous revision of this standard, issued in 2002, incorporates improvements in test methodology and requirements. Based on the results of recent integrated leakage rate tests, the Type A test acceptance criterion previously specified in Appendix F of the standard has been deleted and replaced with a new criterion in the body of the standard. The state of the art of integrated leakage rate test instrumentation has greatly improved since 2002; these improvements are reflected in changes to instrument accuracy requirements specified in this standard.

The examples given in various sections of this standard do not contain or modify any requirements. These examples are for illustration only and are provided to clarify the intent of the text. Furthermore, the examples are not meant to be all-inclusive. Examples of alternative methods or exceptions to general requirements do not constitute permission to categorically apply the exceptions. Each alternative or exception needs to be evaluated to determine its validity and its effect.

ANS standards, including ANSI/ANS-56.8-2020, are available for purchase in the ANS Standards Store at techstreet.com/ans.

Standards continues

Comments requested

Comments are requested on the following standard by June 21, 2021:

■ ANS-15.11-2016 (R2012), *Radiation Protection at Research Reactor Facilities* (reaffirmation of ANSI/ANS-15.11-2016).

This standard establishes the elements of a radiation protection program and the criteria necessary to provide an acceptable level of radiation protection for personnel at research reactor facilities and the public consistent with keeping exposures and releases as low as reasonably achievable.

Comments are requested on the following standards by July 12, 2021:

■ ANS-3.14-202x, *Process for Infrastructure Aging Management and Life Extension of Non-Reactor Nuclear Facilities* (new standard).

This standard addresses requirements for systematically evaluating structures, systems, and components (SSCs) for extending the life of non-reactor nuclear facilities. The standard provides a systematic process to determine the scope of the aging management/life-extension program in terms of SSCs. For those SSCs, a process for evaluating remaining lifetime and determining the need for additional analysis, repairs, inspections, surveillance, testing, and spare-part obsolescence will be developed.

■ ANS-8.14-2004 (R202x), *Use of Soluble Neutron Absorbers in Nuclear Facilities Outside Reactors* (reaffirmation of ANSI/ANS-8.14-2004 [R2016]).

This standard provides guidance for the use of soluble neutron absorbers for criticality control. The standard addresses neutron absorber selection, system design and modifications, safety evaluations, and quality control programs.

Comments are requested on the following standard by July 15, 2021:

■ ANS-15.4-2016 (R202x), *Selection and Training of Personnel for Research Reactors* (reaffirmation of ANSI/ANS-15.4-2016).

This standard sets the qualification, training, and certification criteria for operations personnel at research reactors and establishes the elements of a program for periodic requalification and recertification. The standard is predicated on levels of responsibility rather than on a particular organizational concept.

Comments are requested on the following standard by July 20, 2021:

■ ANS-55.1-202x, *Solid Radioactive Waste Processing System for Light-Water-Cooled Reactor Plants* (revision of ANSI/ANS-55.1-1992 [R2017]).

This standard provides design, fabrication, and performance criteria and guidance for solid radioactive waste processing systems for light water–cooled reactors. The purpose of this standard is to provide criteria to ensure that the solid radioactive waste processing systems are designed, fabricated, installed, and operated in a manner commensurate with the need to protect plant personnel and the health and safety of the public.

PINS

Under the Project Initiation Notification System (PINS), the following standard is being developed:

■ ANS-55.6-2012, *Liquid Radioactive Waste Processing System for Light Water Reactor Plants* (new standard).

This standard provides design, fabrication, and performance criteria and guidance for liquid radioactive waste processing systems for light water–cooled reactors. The purpose of this standard is to provide criteria to ensure that the liquid radioactive waste processing systems are designed, fabricated, installed, and operated in a manner commensurate with the need to protect plant personnel and the health and safety of the public.

All published standards can be ordered through Techstreet at techstreet.com/ans or by calling 855/999-9870. Comments on draft standards should be sent to ANS standards manager Patricia Schroeder at pschroeder@ans.org, with a copy of the comments sent to the Board of Standards Review at the American National Standards Institute.

Volunteer support needed

The following standards projects are in need of volunteer support. Interested individuals should contact standards@ans.org for more information.

- ANS-2.17, *Evaluation of Subsurface Radionuclide Transport at Commercial Nuclear Power Plants* (revision of ANS-2.17-2010 [R2016]).
- ANS-2.18, *Standards for Evaluating Radionuclide Transport in Surface Water for Nuclear Power Sites* (proposed new standard).
- ANS-8.14, *Use of Soluble Neutron Absorbers in Nuclear Facilities Outside Reactors* (revision of ANSI/ANS-8.14-2004 [R2016]).
- ANS-3.13, *Nuclear Facility Reliability Assurance Program (RAP) Development* (proposed new standard).
- ANS-53.1, *Nuclear Safety Design Process for Modular Helium-Cooled Reactor Plants* (revision of ANSI/ANS-53.1-2011 [R2016]).
- ANS-56.2, *Containment Isolation Provisions for Fluid Systems After a LOCA* (new standard, historical revision of ANS-56.2-1984 [W1999]).

Medical community still resists using low-dose radiation to treat COVID-19 patients

By James Conca

Human medical trials began last year on severely ill COVID-19 patients using low doses of radiation. The trials are very small, however—fewer than 25 people—because hospital administrators and the medical community in general are concerned about liability, even though much higher doses are used to treat other diseases, such as cancer.

The first results on a very small group of patients were published in June 2020 in a non-peer-reviewed journal that exists to get critical results out quickly to the scientific and medical communities. The results were quite extraordinary.

Researchers at Emory University Hospital, led by Dr. Mohammad Khan, associate professor of radiation oncology, treated five COVID-19 patients with severe pneumonia who required supplemental oxygen and whose health was visibly deteriorating. Their median age was 90, with a range from 64 to 94. Four were female, four were African American, and one was Caucasian.

These patients were given a single low dose of radiation (1.5 Gy) for 10 to 15 minutes to both lungs, delivered by a front and back beam configuration.

Within 24 hours, four of the patients showed rapid improvement and were discharged from the hospital. Blood tests and repeated imaging of the lungs confirmed that the radiation was safe and effective and did not cause adverse effects—no acute skin, pulmonary, gastrointestinal, or genitourinary toxicities.

The gray (Gy) is a dose unit of ionizing radiation defined as the absorption of one joule of radiation energy per kilogram of matter. Medical doses are different than environmental doses, as they are not whole body but are targeted to a specific organ or tissue. So, 1.5 Gy is quite a low dose for medical uses. Later trials have used 1 Gy or less, down to 0.3 Gy.

Low-dose radiation therapy (LDRT) is critical because severe COVID-19 cases cause cytokine release syndrome, also known as a cytokine storm. Such a storm is a deadly, uncontrolled systemic inflammatory response of the body's immune system resulting from the release of great amounts of pro-inflammatory cytokines, which act as a major factor in producing acute respiratory distress syndrome (ARDS), which is what kills. Chemical anti-inflammatories aren't very effective.

That's why we needed ventilators and ICU beds so badly at the beginning of the pandemic, and why our hospital systems were overwhelmed. The pandemic still poses these threats in places like India.

It's the anti-inflammatory effect of radiation, not its antiviral action, that is invaluable to helping patients with COVID-19. And we are already completely set up for these radiation treatments at almost every hospital and cancer center—no new preparation, additional equipment, or training is needed.

Several papers have appeared on this subject, the two best being "Investigating Low-Dose Thoracic Radiation as a Treatment for COVID-19 Patients to Prevent Respiratory Failure" (George D. Wilson et al., *Radiation Response* [July 2020]), and "COVID-19 Infection: The Perspectives on Immune Responses" (Yufang Shi et al., *Cell Death & Differentiation* [March 23, 2020]).

An immune system macrophage. It is this key immune cell that is stimulated into the correct polarization after a single burst of low-level radiation causes a molecular cascade effect that can reverse the COVID-induced cytokine storm, which is what kills patients. (Source: C. Michael Gibson, Wikipedia)

These studies indicated possible mechanisms by which low doses of radiation mitigate inflammation and facilitate healing, one being the polarization of macrophages to an anti-inflammatory or M2 phenotype. The M1 type tends to overstimulate the immune system, which can lead to a cytokine storm, while the M2 type tends to suppress the overreaction of the immune system.

We anticipated that this would work because the same thing was done 70 to 80 years ago. E. J. Calabrese, at the University of Massachusetts Amherst School of Public Health and Health Sciences, and Gaurav Dhawan, at the University of Massachusetts Amherst, reviewed how X-ray therapy was used during the first half of the 20th century to successfully treat pneumonia, particularly viral pneumonia like that caused by this coronavirus.

As oncologist James S. Welsh, at Loyola University Medical Center in Chicago, puts it, for COVID-19 patients who progress to severe disease, where there is no established treatment and death is a significant possibility, LDRT appears to be a relatively safe strategy that could be widely implemented once evidence of efficacy is produced. This could be readily achieved with small, pragmatic, and expeditious clinical trials, with an extremely rapid clinical signal of benefit.

More information is accumulating concerning the mechanism by which low levels of radiation act. A recent paper by Calabrese et al. (*Radiotherapy & Oncology* [April 2021]) points to the nuclear factor *erythroid* 2–related transcription factor (NRF2) as a main player in the process.

NRF2 is a transcription factor that in humans is encoded by the *NFE2L2* gene. NRF2 is a basic leucine zipper protein that may regulate the expression of antioxidant proteins that protect against oxidative damage triggered by injury and inflammation, as in the case of COVID-19. NRF2 binds to antioxidant response elements (AREs) in the nucleus leading to transcription of ARE genes. NRF2 increases heme oxygenase 1, leading to an increase in phase II enzymes.

NRF2 appears to participate in a complex regulatory network and performs a pleiotropic role, meaning performing multiple actions, in the regulation of metabolism, inflammation, autophagy, proteostasis, mitochondrial physiology, and immune responses, most linked to oxidative stress.

A single, nontoxic, LDRT treatment (0.5–1.0 Gy) activates NRF2, which then mediates cellular antioxidant responses that rebalance the oxidatively skewed redox states of immunological cells, driving them toward anti-inflammatory phenotypes, undermining the cytokine storm just as it's getting started.

Activation of NRF2 by ionizing radiation is highly dose dependent and conforms to the features of a biphasic dose response. At the cellular and subcellular levels, doses of <1.0 Gy induce polarization shifts in the predominant population of lung macrophages (see figure), from an M1 pro-inflammatory

Opinion continues

to an M2 anti-inflammatory phenotype, as mentioned in other studies.

Together, the NRF2-mediated antioxidant responses and the subsequent shifts to anti-inflammatory phenotypes have the capacity to suppress cytokine storms, resolve inflammation, promote tissue repair, and prevent COVID-19–related mortality.

As seen in the few clinical trials to date, optimal life-saving potential occurs when LDRT is applied to the lungs just prior to the cytokine storms and well before the patients are placed on mechanical oxygen ventilators. The administration of LDRT either as an intervention of last resort or too early in the disease progression may be far less effective in saving the lives of ARDS patients because the oxidative state of the macrophages is less important at those points. We have seen this in a recent trial in which COVID-19 patients with well-advanced cases were already on ventilation. The LDRT had no meaningful effect.

With this much understanding of how LDRT works, the successful applications in the 20th century, and the high mortality rate of COVID-19 patients after breathing difficulties begin, you would think that the medical community would jump in with both feet, particularly radiation oncologists and radiobiologists, who routinely use much higher doses—up to 100 times higher—to treat various cancers.

And a few have. But the long-standing fear of radiation and the generally conservative nature of the medical community, which subscribes to the linear no-threshold hypothesis, knowingly or not, have combined to keep any meaningful action from occurring, even to the point of preventing human trials.

So only a few very small human trials have occurred, with mostly good results, but not to the point of the large, double-blind studies required for full acceptance. And even getting volunteers for low-dose radiation studies is difficult because people are afraid of radiation, and their doctors are also generally ignorant of radiation effects.

An indication of this is the recent nixing of a large, well-planned human trial involving a group of over 20 investigators, representing more than 15 clinical sites, centered on a large university medical center. Almost 100 patients would have been enrolled in a double-blind study that would also have looked at the effects of different doses, 35 cGy and 100 cGy.

The trial was to focus on COVID-19 patients at the correct point for LDRT intervention, after oxygen was needed but before mechanical ventilation was required. The medical center's institutional review board, the regulatory body that governs medical research on humans, gave its approval. At the last minute, however, the university administration canceled the trial for fear of liability—a highly unusual and wrong-headed move, since the IRB, which is considered the last word, had given its approval.

With such general pushback and unwarranted fear of radiation, it is no wonder that our society allowed hundreds of thousands of Americans to die of COVID-19 who did not need to die. This is even more horrific and unethical than patients not getting X-ray diagnostics to determine health problems, or even suppressing nuclear power to address climate change.

James Conca is a scientist in the field of the earth and environmental sciences, specializing in geologic disposal of nuclear waste, energy-related research, planetary surface processes, radiobiology and shielding for space colonies, and subsurface transport and environmental cleanup of heavy metals. Conca also writes about nuclear, the environment, and energy for Forbes*; you can view his stories online at forbes.com/sites/jamesconca.*

Fluor Corporation has announced that **Peter J. Fluor**, great-grandson of company founder John Simon Fluor, is retiring from the company's board of directors. He was the last in a long line of Fluor family members to serve as a leader within the company since its founding in 1912. Peter Fluor has served on Fluor's board of directors since 1984 in a variety of roles, including as lead independent director from 2003 to 2020.


Fluor


Frenzel


Fowke

Robert Frenzel will succeed **Ben Fowke** as chief executive officer at Xcel Energy. Fowke, who was named Xcel's chairman, president, and CEO in August 2011, is retiring as CEO effective August 18 but will remain on the company's board of directors and will serve as executive chairman during a transition period. He also serves on the board of the Nuclear Energy Institute. Frenzel, who joined Xcel as chief financial officer in 2016, is currently Xcel's president and chief operating officer.

NRG Energy has announced the appointment of **Alberto Fornaro** as executive vice president and chief financial officer. He succeeds **Gaetan Frotte**, who had been serving as interim CFO, in addition to his responsibilities as senior vice president and treasurer, since February. Fornaro was previously CFO of Coupang, a South Korea–based e-commerce company.


Fornaro

Lightbridge president and chief executive officer **Seth Grae** has been reappointed by U.S. secretary of commerce Gina Raimondo to the Civil Nuclear Trade Advisory Committee (CINTAC). Composed of private-sector representatives from the nuclear power industry, CINTAC meets periodically throughout the year to discuss trade issues facing the U.S. civil nuclear sector, contribute to policy discussions, and work with government leaders.


Grae

Master-Lee Energy Services has elected **Thomas M. Tallarico** as president following the unexpected death of former president **Louis P. Acito** in April. Tallarico has served in various capacities during his 29-year career at


Tallarico

People continues

Master-Lee, starting as an accountant, and most recently serving as chief financial officer.


Skaggs

Michael D. Skaggs, executive vice president and chief operating officer of the Tennessee Valley Authority, has announced plans to retire in January 2022. He will continue to serve until TVA selects a new chief operating officer. Skaggs, who has more than 35 years of experience in the utility industry—26 of them with TVA—was named COO in 2018. Under his leadership, TVA brought Watts Bar-2 into commercial operation in 2016, generating the United States' first new nuclear energy of the 21st century.

The Nuclear Regulatory Commission recently named three new resident inspectors. **Russell Cassara II** is the

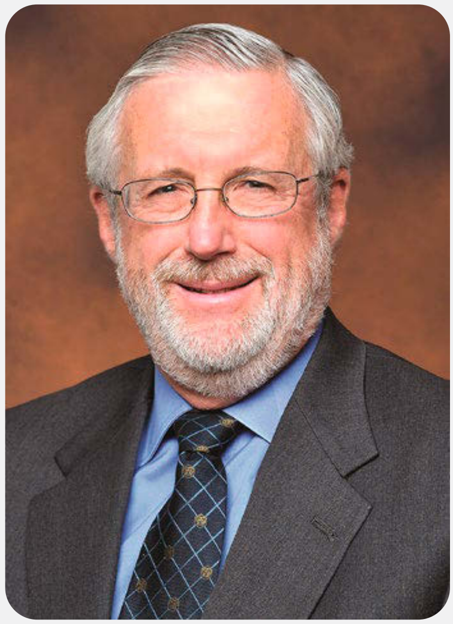

Cassara


Donley

new resident inspector at the Davis-Besse plant in Oak Harbor, Ohio. Cassara joined the NRC in 2020 in the Region III office as a reactor engineer. **Amber Donley** was named

Obituaries

Peter B. Lyons (1943–2021)



Peter B. Lyons, 78, ANS Fellow and member since 2003, former Nuclear Regulatory Commission commissioner (2005–2009) and assistant secretary of energy for nuclear energy (2011–2015), died April 29.

Born on February 23, 1943, Lyons earned a bachelor's degree in physics and math from the University of Arizona in 1964 and a Ph.D. in astrophysics from the California Institute of Technology in 1969. Lyons started his nuclear science and technology career at Los Alamos National Laboratory. In 1997, after nearly three decades at LANL, he joined the staff of Sen. Pete Domenici (R., N.M.) as a scientific advisor. In this role, he crafted Domenici's "A New Nuclear Paradigm" speech, which set the foundation for the resurgence of nuclear power in the United States. Lyons also helped Domenici lay the groundwork for the Nuclear Energy Research Initiative and the Generation IV Nuclear Energy Systems program.

Lyons was sworn in as an NRC commissioner on January 25, 2005, and he served until his term ended on June 30, 2009. At the NRC, he focused on the safety of operating reactors, even as new reactor licensing and possible construction emerged. He was a consistent voice for improving partnerships with international regulatory agencies. He emphasized active and forward-looking research programs to support sound regulatory decisions, address current issues, and anticipate future ones. He was also a strong proponent of science and technology education. At the Department of Energy, Lyons championed efforts to secure federal funding for small modular reactor development and for the Nuclear Energy University Program, among many other contributions to the future of nuclear energy.

In 2020, ANS's Nuclear Nonproliferation Policy Division honored Lyons with the Dwight D. Eisenhower Medal for his influential leadership in nuclear technology policy over five decades.

"For decades, Pete distinguished himself as an influential thought leader in nuclear science and energy policy, first at LANL and later at the NRC and DOE," said NRC chairman Christopher T. Hanson. "He was a mentor, a friend, and a role model for public service. We are deeply saddened over the loss of this great man."

resident inspector at the Columbia nuclear plant near Richland, Wash. Donley, who joined the NRC in 2020, previously worked at the Peach Bottom plant in Pennsylvania as a radiochemist. **Casey Smith** is the new resident inspector at the Harris plant in New Hill, N.C. Smith joined the NRC in 2019 as a reactor engineer in the Office of Nuclear Reactor Regulation.

Kudos

Robert L. Sindelar, ANS member since 2011, is the recipient of the South Carolina Governor's Award for Excellence in Scientific Research for 2021. The award honors an individual or team within the state whose achievements and contributions to science in South Carolina merit special recognition to promote wider awareness of the quality and extent of scientific activity in South Carolina. Sindelar joined Savannah River Laboratory, now Savannah River National Laboratory, in 1986 as a research engineer. He is currently a consulting engineer and laboratory fellow at SRNL.

Sindelar

Don Olander: A remembrance

By Arthur Motta

It is my sad duty to write a remembrance of Don Olander, who was my doctoral advisor, longtime mentor, and, later, textbook coauthor. Don passed away in April. His career spanned the era of nuclear power. He earned his doctorate from the Massachusetts Institute of Technology just two years after the first commercial nuclear power plant in the United States started operation. He joined the faculty at the University of California–Berkeley in 1958 and retired in 2007. I say "retired," but he kept hard at work on writing our jointly authored textbook, more than keeping me on my toes. During his time at UC Berkeley, he taught and mentored a whole generation of nuclear materials engineers.

Don received many honors throughout his life, among which were Fellow of the American Nuclear Society and membership in the National Academy of Engineering. In 1999, a special edition of the *Journal of Nuclear Materials* was published in his honor. In that issue, papers by his former students and current colleagues, by their very presence, bore testimony to his impact on the field of nuclear materials. The great appreciation and admiration that his former students and colleagues felt for him clearly showed.

The physical difficulty and the complexity of the nuclear materials problems he studied were great. Don somehow always managed to capture the complexity of the issue by focusing on the critical aspect of the problem, identifying which crucial experiment to make and which modeling approach to take, and then presenting the results in clear mathematical language. He combined great knowledge about the experimental setup and an arsenal of mathematical tools he brought to bear on the theoretical analysis and interpretation of the data. Because of this, his research produced knowledge and understanding beyond mere data gathering and empirical modeling. The intellectual rigor with which he approached these problems was an inspiration and a guide for all of us who worked with him.

Don's teaching and writings and his research will continue to bear witness to his impact, as will the careers of those of us who have been fortunate enough to model them on his lasting intellectual approach and personal integrity.

Arthur Motta is a professor and chair of the Nuclear Engineering Program at Penn State University. Motta and Olander coauthored Light Water Reactor Materials, *volumes I and II. ANS published volume I in 2017, and volume II is to be published this year.*

Index to Advertisers

Since the magazine accepted its first advertisement in 1960, Nuclear News has proudly partnered with hundreds of vendors and organizations to help keep the worldwide nuclear field informed about the latest products and services, conferences and events, employment opportunities, and academic/training courses. If you are performing or seeking nuclear-related work, make sure advertising in our magazine is part of your business development strategy and annual budget.

View ads and request product/service information from this and past issues at: ans.org/advertising/nn/da.

ans.org/advertise | advertising@ans.org

The publisher does not assume any liability for errors or omissions. The index is provided as an additional reader service.

July

July 5–8—**The Society for Radiological Protection Annual Conference**, Bournemouth, U.K. srp-uk.org/events/2021AnnualConference

● July 8—**Nuclear Solutions Exhibition**, Warrington, U.K. https://nuclear-solutions.co.uk/
Meeting has been rescheduled to August 25, 2021

July 13–15—**ASME Pressure Vessels and Piping Conference (PVP 2021)**, virtual meeting. event.asme.org/PVP

July 16–23—**2021 IEEE Nuclear and Space Radiation Effects Conference (NSREC)**, virtual meeting. nsrec.com/nsrec_2021.html

● July 19–22—**47th Annual Nuclear Information Technology Strategic Leadership (NITSL)**, virtual meeting. nitsl.org/conference

● July 19–23—**ASME/EPRI Radwaste Workshop and EPRI International Low- and Intermediate-Level Waste Conference and Vendor Expo**, virtual meeting. epri.com/research/programs/061197/events/38EA3DCD-0829-45CD-B45A-5F3E8FA0EEFB

● July 20—**Nuclear Fuel Supply Forum**, virtual meeting. nei.org/conferences/nuclear-fuel-supply-forum

July 20–22—**Power 2021**, virtual meeting. event.asme.org/POWER

July 21–22—**Enlit Australia**, Melbourne, Australia. enlit-australia.com

● July 25–29—**66th Annual Health Physics Society Meeting**, Phoenix, Ariz.

● July 28—**Savannah River Federal Business Opportunities Forum (ETEBA)**, virtual meeting. eteba.org/savannahriverforum/

July 28–30—**48th Annual Review of Progress in Quantitative Nondestructive Evaluation**, virtual meeting. event.asme.org/QNDE

August

● Aug. 2–3—**Women In Nuclear National Conference**, virtual meeting. nei.org/conferences/women-in-nuclear

Aug. 2–6—**Technical Meeting on Good Practices for the Operation and Maintenance of Research Reactors**, Vienna, Austria. iaea.org/events/evt1904070

Aug. 3–5—**13th Annual Nuclear Deterrence Summit**, Alexandria, Va. deterrencesummit.com/

Aug. 4–6—**28th International Conference on Nuclear Engineering (ICONE 28)**, virtual meeting. event.asme.org/ICONE

■ Aug. 8–11—**Utility Working Conference and Vendor Technology Expo**, Marco Island, Fla. ans.org/meetings/view-uwc2021/

Aug. 23–26 and Aug. 30–Sep. 1—**INMM & ESARDA Joint Annual Meeting**, virtual meeting. inmm.org/mpage/INMMESARDA2021

Aug. 23–Sep. 3—**International School of Nuclear Law (ISNL)**, Montpellier, France. oecd-nea.org/law/isnl

● Aug. 25—**Nuclear Solutions Exhibition**, Warrington, U.K. https://nuclear-solutions.co.uk/

Aug. 25–27—**KONTEC 2021**, Dresden, Germany. kontec-symposium.com/

✖ Aug. 29–Sep. 3—**2021 International Topical Meeting on Probabilistic Safety Assessment and Analysis (PSA 2021)**, Columbus, Ohio. psa.ans.org/2021
Meeting has been rescheduled to November 7–12, 2021

Aug. 30–Sep. 3—**International Conference on Operational Safety of Nuclear Power Plants**, Beijing, China. iaea.org/events/international-conference-on-operational-safety-of-nuclear-power-plants-2021

Meetings listed in the calendar that are not sponsored by ANS do not have the endorsement of ANS, nor does ANS have financial or legal responsibility for these meetings.

Calendar continues

September

- Sep. 5–10—**Particles and Nuclei International Conference (PANIC 2021)**, virtual meeting. indico.lip.pt/event/592/

Sep. 6–9—**30th International Conference Nuclear Energy for New Europe (NENE 2021)**, Bled, Slovenia. djs.si/nene2021/

Sep. 7–9—**16th IAEA-FORATOM Joint Event on Management Systems—Management Systems for a Sustainable Nuclear Supply Chain**, virtual meeting. events.foratom.org/mse2021/

- Sep. 8–10—**2021 National Cleanup Workshop**, Alexandria, Va. cleanupworkshop.com/home-1.html

Sep. 8–10—**World Nuclear Association Symposium 2021**, London, U.K. wna-symposium.org/

Sep. 8–10—**RICOMET 2021**, Budapest, Hungary. ssh-share.eu/ricomet2021/

✖ Sep. 12–16—**14th International Conference on Radiation Shielding and 21st Topical Meeting of the Radiation Protection and Shielding Division (ICRS 14/RPSD 2021)**, Seattle, Wash. ans.org/meetings/icrs14rpsd21/ ***Meeting has been postponed until September 25–29, 2022***

- Sep. 12–17—**Applied Nuclear Physics (ANP) Conference 2021**, Prague, Czech Republic. anpc2021.cz/

Sep. 13–15—**International Conference on Decommissioning Challenges: Industrial Reality, Lessons Learned and Prospects**, Avignon, France. sfen-dem2021.org/

- Sep. 13–17—**2021 European Conference on Radiation and Its Effects on Components and Systems (RADECS)**, Vienna, Austria. seibersdorf-laboratories.at/en/radecs-2021

Sep. 15–17—**CNA2021**, virtual meeting. conference2021.cna.ca/

- Sep. 19–23—**Materials in Nuclear Energy Systems (MiNES) 2021**, Pittsburgh, Penn. tms.org/MINES2021

Sep. 20–21—**Decommissioning Strategy Forum**, Las Vegas, Nev. decommissioningstrategy.com/

Sep. 21–22—**Advanced Clean Energy Summit (ACES 2021)**, virtual meeting. event.asme.org/ACES

Sep. 22–24—**RadWaste Summit**, Las Vegas, Nev. radwastesummit.com/

Sep. 23–24—**Valve World Expo & Conference Asia 2021**, Shanghai, China. valve-world.net/vwa2021/valve-world-asia-2021.html

Sep. 27–28—**2nd International Conference of Materials, Chemistry and Fitness-for-Service Solutions for Nuclear Systems (MCFD 2021)**, virtual meeting. cns-snc.ca/events/mcfd2021/

Sep. 27–30—**European Nuclear Young Generation Forum (ENYGF 2021)**, Tarragona, Spain. enygf.org/

Sep. 27–Oct. 1—**NPC 2021: International Conference on Nuclear Plant Chemistry**, Antibes, France. new.sfen.org/evenement/npc-2021/

Sep. 28–30—**Enlit Asia**, Jakarta, Indonesia. enlit-asia.com/

October

■ Oct. 3–7—**International Conference on Mathematics and Computational Methods Applied to Nuclear Science and Engineering (M&C 2021)**, Raleigh, N.C. mc.ans.org

Oct. 4–5—**2021 AtomExpo**, Sochi, Russia. 2021.atomexpo.ru/en/

Oct. 4–6—**International Conference on Environmental Remediation and Radioactive Waste Management (ICEM 2021)**, virtual meeting. asme.org/conferences-events/events/international-conference-on-environmental-remediation-and-radioactive-waste-management

- Oct. 5–7—**ETEBA Business Opportunities & Technical Conference**, Knoxville, Tenn. https://eteba.org/botc/

Oct. 12–13—**TotalDECOM 2021**, Manchester, U.K. totaldecom.com/2021-expo-manchester/

■ Oct. 16–20—**2021 International Congress on Advances in Nuclear Power Plants (ICAPP2021)**, Abu Dhabi, UAE. icapp2021.org/

- Oct. 16–23—**2021 IEEE Nuclear Science Symposium and Medical Imaging Conference (NSS/MIC)**, virtual meeting. nssmic.ieee.org/2021/

- Oct. 17–21—**2021 Test, Research and Training Reactors (TRTR) Annual Conference**, Raleigh, N.C. projects.ncsu.edu/mckimmon/cpe/opd/trtr/

- Oct. 18–21—**Experience POWER**, San Antonio, Texas experience-power.com/

Oct. 24–28—**TopFuel 2021**, Santander, Spain. euronuclear.org/topfuel2021

Oct. 25–29—**Technical Meeting on Artificial Intelligence for Nuclear Technology and Applications**, virtual event. iaea.org/events/evt2004304

Oct. 27–28—**All-Energy Australia**, Melbourne, Australia. all-energy.com.au/en-gb.html

Oct. 27–29—**POWERGEN India**, New Delhi, India. powergen-india.com/

November

- ■ Nov. 7–12—**2021 International Topical Meeting on Probabilistic Safety Assessment and Analysis (PSA 2021)**, Columbus, Ohio. psa.ans.org/2021

Nov. 8–12—**International Conference on a Decade of Progress after Fukushima-Daiichi: Building on the Lessons Learned to Further Strengthen Nuclear Safety**, Vienna, Austria. iaea.org/events/international-conference-on-a-decade-of-progress-after-fukushima-daiichi-building-on-the-lessons-learned-to-further-strengthen-nuclear-safety-2021

- ● Nov. 14–21—**FUSION20**, Shizuoka City, Japan. asrc.jaea.go.jp/soshiki/gr/HENS-gr/fusion20/index.html

Nov. 15–17—**NESTet 2021—Nuclear Education & Training Conference**, Brussels, Belgium. ens.eventsair.com/nuclear-education-and-training/

Nov. 30–Dec. 2—**Enlit Europe**, Milan, Italy. enlit-europe.com/live

Nov. 30–Dec. 2—**World Nuclear Exhibition**, Paris, France. world-nuclear-exhibition.com/

- ■ Nov. 30–Dec. 4—**2021 ANS Winter Meeting and Technology Expo**, Washington, D.C. ans.org/meetings/wm2021/

December

- ● Dec. 1–3—**Perma-Fix 18th Annual Nuclear Waste Management Forum**, Nashville, Tenn. ir.perma-fix.com/upcoming-events/detail/824/perma-fixs-18th-annual-nuclear-waste-management-forum
- ● Dec. 12–16—**23rd IEEE Pulsed Power Conference (PPC) and the 29th IEEE Symposium on Fusion Engineering (SOFE)**, Denver, Colo. uta.engineering/ppcsofe2021/

Call for Papers

ICRS 14/RPSD-2022

14th International Conference on Radiation Shielding and 21st Topical Meeting of the Radiation Protection and Shielding Division

September 25-29, 2022 | Seattle, WA, USA | Seattle Marriott Waterfront

CALL FOR PAPERS

EXECUTIVE CHAIRS

Honorary Cochairs
Enrico Sartori (NEA, ret.)
Takashi Nakamura (Tohoku Univ, ret.)
Nolan Hertel (Georgia Tech)
Bernadette Kirk (ORNL, ret.)

General Chair
Shaheen Dewji (Texas A&M)

General Cochairs
David Dixon (LANL)
Irina Popova (ORNL)

Technical Program Chair
Pedro Vaz (Instituto Superior Técnico)

Technical Program Cochairs
Jeffrey Favorite (LANL)
Thomas Miller (ORNL)
Rui Qiu (Tsinghua U.)

Student Cochairs
Alex Perry (TAMU)
Kathryn Bales (UT-San Antonio)

SUMMARY DEADLINE: TUESDAY, MARCH 15, 2022

MARCH	SUBMISSION OF SUMMARIES: **Tuesday, March 15, 2022**
MARCH	FIRST REVIEW COMPLETED: **Wednesday, March 30, 2022**
APRIL	REVISED SUMMARIES DUE: **Monday, April 18, 2022**
MAY	AUTHOR NOTIFICATION OF ACCEPTANCE: **Monday, May 2, 2022**

ABOUT THE MEETING

We are proud to follow in the long tradition of joint RPSD-ICRS meetings and hope to achieve the success of the last meeting in Paris (2016). Our meeting vision is to ensure attendees leave with renewed interest in their field of expertise by exposing them to new tools that make them more effective, showing them the value of membership in the RPSD and ICRS communities, and providing an enjoyable destination for the meeting. We hope to provide an environment for tool developers, code users, theoreticians, and experimentalists to engage in productive discussions, establish collaborations, and build community in the foreground of scientific advancements and challenges in radiation protection and shielding.

PROPOSED WORKSHOPS

- MCNP® version 6.2 Open Lab
- NJOY
- Exnihilo (Denovo/Shift)
- Proton Therapy
- Attila4MC
- PHITS
- ITS/SCEPTER
- Uncertainty Quantification
- MCNP6 associated packages ISC, MCNPTools, and DRiFT
- ADVANTG

PROPOSED SPECIAL SESSIONS

(If you have an idea for an additional Special Session, please contact the conference organizers to propose it.)

- Radiation Protection and Shielding Applications for Pulsed Reactors
- Radiation Shielding and Dosimetry for Criticality Safety
- CAD to MCNP Methods
- Nanomaterial Shielding
- Applications of Machine Learning
- Radiation Protection for Ionizing Radiation Generated from High-Intensity Laser Facilities
- Latest Results from RERF Using State-of-the-Art Phantoms
- Shielding Benchmarks including SINBAD and ICSBEP
- Fukushima Eleven Years Later

LOCATION: SEATTLE MARRIOTT WATERFRONT

- Seattle Aquarium
- Pike Street Market
- Space Needle
- Museum of History and Industry
- Pacific Science Center
- Museum of Pop Culture
- All within a mile of the hotel

SUBMIT A SUMMARY

epsr.ans.org/meeting/?m=354

PROGRAM SPECIALIST

Janet Davis
708-579-8253
jdavis@ans.org

Call for Papers

ICRS 14/RPSD-2022

14th International Conference on Radiation Shielding and 21st Topical Meeting of the Radiation Protection and Shielding Division

September 25-29, 2022 | Seattle, WA, USA | Seattle Marriott Waterfront

TOPICS OF INTEREST

TRACK 1: RADIATION SHIELDING
TRACK 2: HEALTH PHYSICS
TRACK 3: DOSIMETRY
TRACK 4: DETECTION AND MEASUREMENT
TRACK 5: UNCERTAINTY QUANTIFICATION AND SENSITIVITY ANALYSIS
TRACK 6: NUCLEAR AND ATOMIC DATA
TRACK 7: SPACE APPLICATIONS
TRACK 8: MONTE CARLO METHODS
TRACK 9: DETERMINISTIC METHODS
TRACK 10: HYBRID METHODS
TRACK 11: EXPERIMENTAL VALIDATION
TRACK 12: REACTOR FACILITIES
TRACK 13: ACCELERATOR FACILITIES
TRACK 14: MEDICAL FACILITIES
TRACK 15: FUSION FACILITIES
TRACK 16: FUEL CYCLE AND WASTE MANAGEMENT FACILITIES
TRACK 17: MEDICAL PHYSICS
TRACK 18: ACTIVATION MEASUREMENT AND ANALYSIS
TRACK 19: DECOMMISSIONING
TRACK 20: NONPROLIFERATION AND NUCLEAR SECURITY APPLICATIONS

GUIDELINES

Submit summaries describing work that is of value to the nuclear industry. All accepted summaries will be published in the Proceedings of the Topical. Summaries are presented orally at the meeting, and presenters are expected to register for the meeting. Completed summaries may be published elsewhere, but the summaries become the property of ANS. Under no circumstances should a summary be published in any other publication prior to presentation at the ANS meeting. An ANS copyright form is required for all summaries and posters.

FORMAT

We are soliciting one- to four-page summaries in the format of ANS Transactions summaries. Templates and guidelines are available at **www.ans.org/pubs/transactions/**. Summaries not formatted according to the template will be rejected. Summaries exceeding four pages will be rejected. Accepted summaries will be published in the Proceedings of the Topical.

POSTERS

Authors desiring a poster presentation must also submit a summary in the proper format as described above.

JOURNAL COLLABORATION

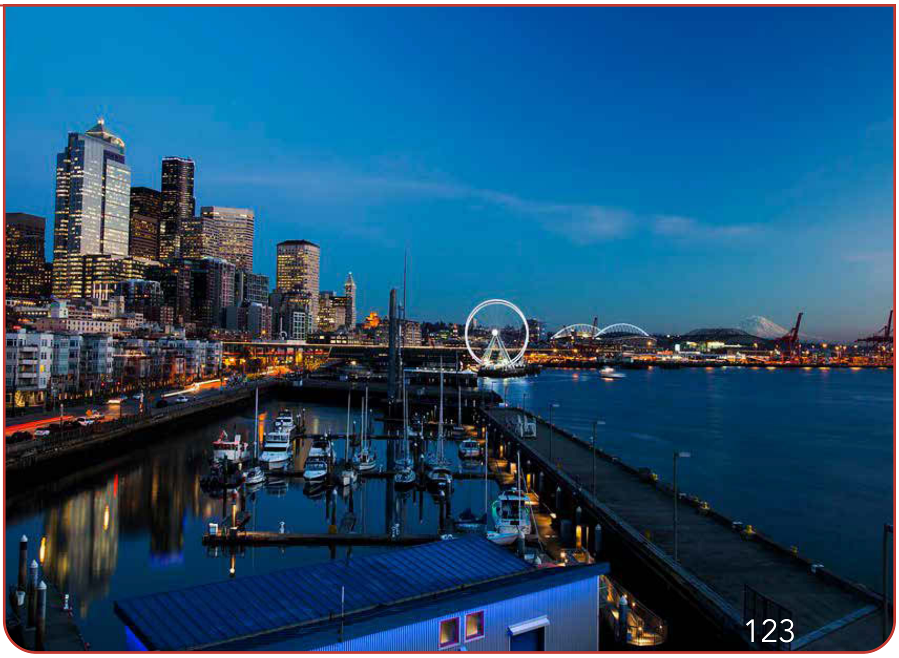
We will invite some authors to submit a full-length journal article for a special issue of Nuclear Science and Engineering.

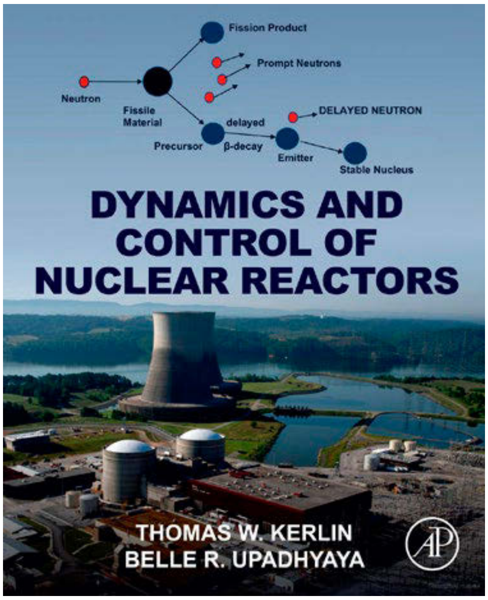
MEETING ORGANIZING COMMITTEE

Exhibits and Sponsorship Chair
Avneed Sood (LANL)

Workshop Chair
Joel Risner (ORNL)

Social Media Chair
Autumn Kalinowski (TAMU)





Dynamics and Control of Nuclear Reactors

By Thomas W. Kerlin and Belle R. Upadhyaya

Book review by John Bernard

This book is a most useful and most welcome addition to the literature on the dynamics and control of nuclear fission reactors. The authors, both of whom are associated with the University of Tennessee, have been leaders in this field for decades.

The book itself is innovative in several respects. First, it incorporates a modular modeling approach so that students can readily perform simulations of what is being studied. Second, it covers many different reactor designs (pressurized water reactors, boiling water reactors, CANDU reactors, and Generation IV reactors) so that the learned material can be readily applied to real-world reactors. Third, it treats both the kinetic and thermal behavior of fission reactors. Fourth, it contains some esoteric topics, such as the operation of molten salt reactors.

This book, published in 2019 by Academic Press, is substantially different from previous texts on the subject that have tended to develop some aspect of control theory in detail and then apply that concept to a single reactor design, usually modeled as simplified point kinetics. The book contains 16 chapters that address reactor design, point and space-time kinetics, reactor startup, feedback effects (fission product and temperature), thermal-hydraulic behavior, instrumentation, reactor types, basic control theory, accidents, and simulations.

There are also 11 appendices that, among other things, expand upon certain aspects of control theory, introduce MATLAB, or summarize reactor physics. These appendices are intended as either refreshers for professionals or detailed introductions for those entering the field. The book can therefore be of benefit to both those new to the field and those with experience. The former, undergraduates or first-year graduate students, would probably wish to concentrate on the chapters themselves. Advanced graduate students and professionals would find the material in certain appendices to be of value, depending on their background.

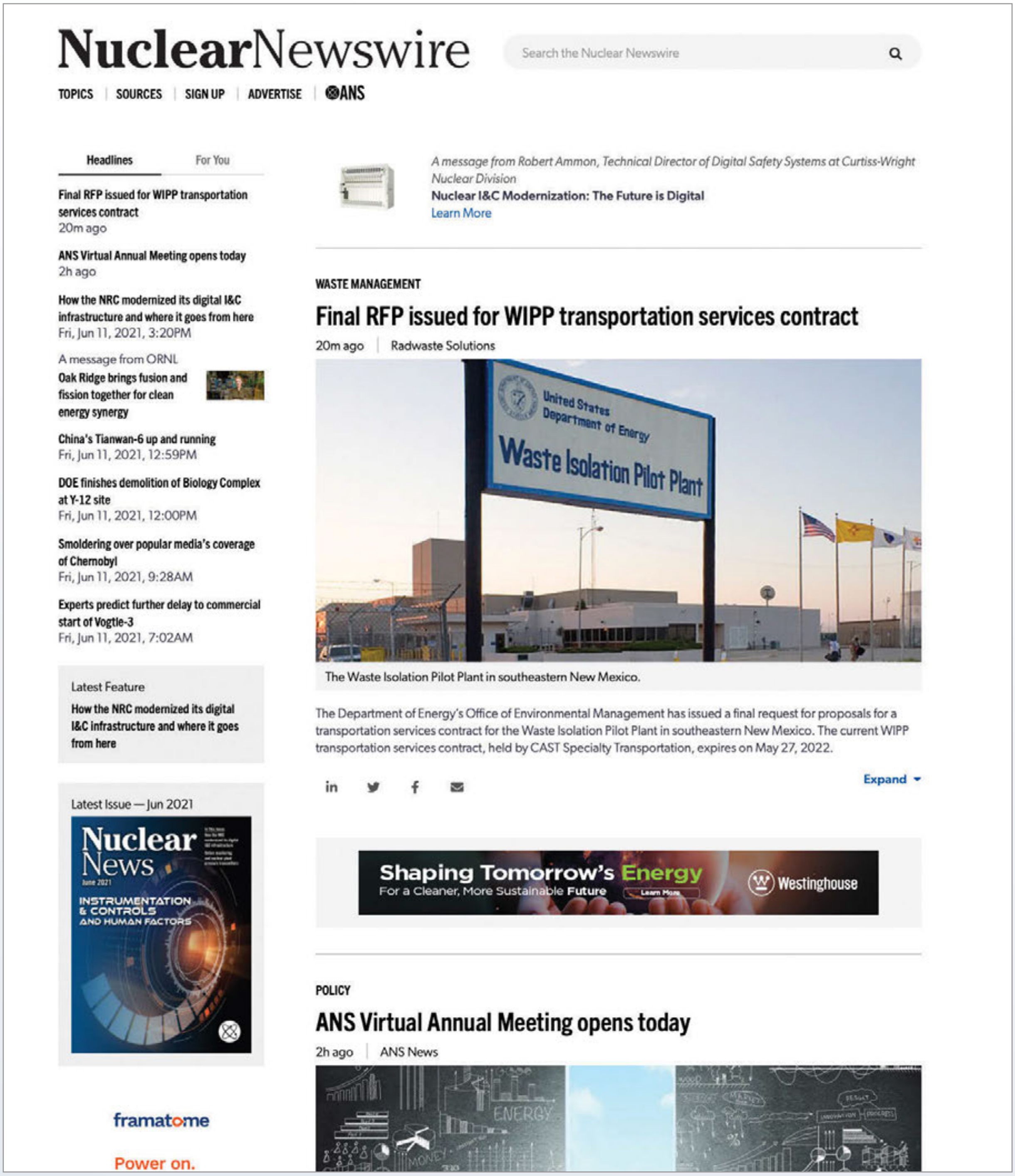
While the book is intended as a textbook, it would also make a useful reference, because it contains material on a wide range of topics. Another outstanding feature of this book is its use of diagrams and drawings, which are large, well-labeled, and numerous.

The book assumes some knowledge of reactor physics and therefore would be best used in a course for third- or fourth-year undergraduates or for graduate students. Certain chapters need not be read in sequence; thus, instructors can tailor the material to their own course preferences by selecting the appropriate chapters and/or appendices. For maximum benefit, those using this book should be familiar with MATLAB or an equivalent.

John Bernard is a former principal research engineer in the Nuclear Science and Engineering Department at the Massachusetts Institute of Technology.

Now Live!

The newly redesigned ANS online news page launched in April!
Check out **ans.org/news** for your daily nuclear news.

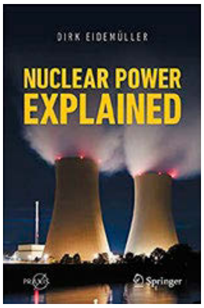


Premium Sponsored Content and Banner Ad positions are available to vendors on this webpage and in the corresponding Nuclear Newswire weekly email, which recaps the top trending headlines and is delivered to more than 35,000 subscribers every Friday!

Online:	Availability:	Questions:
www.ans.org/advertising	**advertising@ans.org**	**708-579-8225**

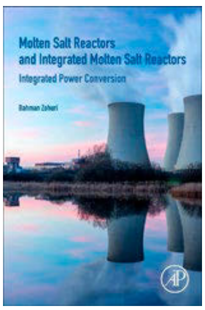
ANS

Recently Published

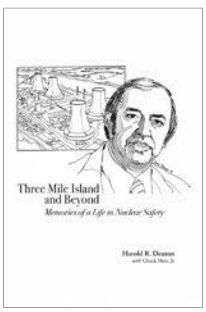


Nuclear Power Explained, by Dirk Eidemüller. This book explains everything one would want to know about nuclear power in a compelling and accessible way. Split into three parts, it walks readers through the basics of nuclear physics and radioactivity; the history of nuclear power usage, including the most important events and disasters; the science and engineering behind nuclear power plants; the politics and policies of various nations; and finally, the long-term societal impact of nuclear technology, from uranium mining and proliferation to final disposal.

Featured along the way are dozens of behind-the-scenes, full-color images of nuclear facilities. Written in a nontechnical style with minimal equations, this book will appeal to lay readers, policymakers, and professionals looking to acquire a well-rounded view about this complex subject. (310 pages, softcover, $29.99, ISBN 978-3-030-72669-0, Springer International Publishing; order at springer.com/gp)



Molten Salt Reactors and Integrated Molten Salt Reactors: Integrated Power Conversion, by Bahman Zohuri. This book serves as a critical reference covering the main steps for the application of molten salt reactors and integrated molten salt reactors. The book reviews the past, current, and future states of these reactors, including pros and cons, designs and safety features involved, and additional references. It includes coverage of material, economic, and technical challenges involved with waste heat recovery, power conversion systems, and advanced computational materials proposed for Generation IV systems. Advanced nuclear open air-Brayton cycles are also included for higher efficiency. Rounding out with guidance on avoiding salt freezing and salt cleanup for fission and fusion reactors, this book provides today's nuclear engineer and power plant engineer with the impactful content of rising efficiency in molten salt reactors, ultimately leading to more efficient and affordable electricity. (300 pages, paperback, $170, ISBN 978-0-323-90638-8, Academic Press; order at elsevier.com/books)



Three Mile Island and Beyond: Memories of a Life in Nuclear Safety, by Harold R. Denton, with Chuck Metz Jr. During the fear-filled days of the Three Mile Island accident, Harold Denton's voice was one of reassuring and convincing comfort to the American people. *Three Mile Island and Beyond* interweaves Denton's retelling of the accident with chapters conveying his career-long message of safety being the paramount factor in the use of nuclear technology. (200 pages, softcover, $29.95 [$26.95 for ANS members], ISBN 978-0-89448-590-9, American Nuclear Society; order at ans.org/store)

The following are listings of the most recent issues of ANS's three technical journals. ANS members, access your free electronic subscription by visiting ans.org/pubs/journals and signing in to your ANS account.

ANS Technical Journals

FUSION SCIENCE AND TECHNOLOGY • JULY 2021

Experimental Investigation of Thermal Properties of Materials Used to Develop Cryopump *R. Gangradey et al.*

The Digital Assembly and Maintenance Training Platform for ITER-Type Mock-Up in Virtual Reality Environment *J.-Y. Li et al.*

The Development and Testing of a Digital ITER-Type Mock-Up Based on Virtual Reality Technology *J.-Y. Li et al.*

Plasma Diagnostics on Pulse Plasma-Focus Generators and Their Features as Alternative Fusion Reactors *A. Zhukeshov et al.*

Design of Higher-Order Circular Array Antenna with Multiple Patch Elements Based on Angular Momentum *R. Krishnamoorthy et al.*

Comparison of Properties of the Hydrophobic Catalyst RCTU-3SM in Reactions of Isotope Exchange Between Hydrogen and Water Vapors and Oxidation of Trace Hydrogen in Gas Flows *A. N. Bukin et al.*

Synthesis, Characterization, and Hydrogen Isotope Storage Properties of $Zr_{1-x}Ti_xCo$ and $Zr_{1-x}Hf_xCo$ Alloys ($x = 0.1, 0.2$) *B. F. Monea et al.*

Preliminary Accident Analysis of Ex-Vessel LOCA for the European DEMO HCPB Blanket Concept *X. Z. Jin*

A Band Rejection Filter of High Current Radio Frequency Ion Source for Neutral Beam Injector *W. Liu et al.*

NUCLEAR SCIENCE AND ENGINEERING • JULY 2021

Neutron Transmission and Capture Measurements of ^{133}Cs from 600 to 2000 eV *R. C. Block et al.*

A New Resonance Calculation Method Using Energy Expansion Based on a Reduced Order Model *R. Kondo et al.*

Post-Neutron Mass Yield Distribution in the Spontaneous Fission of ^{252}Cf *H. Naik et al.*

Transient Multilevel Scheme with One-Group CMFD Acceleration *Q. Shen et al.*

A New Embedded Analysis with Pinwise Discontinuity Factors for Pin Power Reconstruction *H. Yu et al.*

Extended Applications of Subgrid Representation in the 2D/1D Method *S. Stimpson et al.*

NUCLEAR TECHNOLOGY • JULY 2021

This fully open access special issue features 13 papers on MOOSE and related codes.

Scalable Feature Tracking for Finite Element Meshes Demonstrated with a Novel Phase-Field Grain Subdivision Model *C. J. Permann et al.*

Automatic Differentiation in MetaPhysicL and Its Applications in MOOSE *A. Lindsay et al.*

Continuous Integration, In-Code Documentation, and Automation for Nuclear Quality Assurance Conformance *A. E. Slaughter et al.*

Method of Characteristics for 3D, Full-Core Neutron Transport on Unstructured Mesh *D. Gaston et al.*

BISON: A Flexible Code for Advanced Simulation of the Performance of Multiple Nuclear Fuel Forms *R. L. Williamson et al.*

Grizzly and BlackBear: Structural Component Aging Simulation Codes *B. W. Spencer et al.*

Multiscale Simulations of Thermal Transport in W-UO_2 CERMET Fuel for Nuclear Thermal Propulsion *M. Sessim, M. R. Tonks*

Pronghorn: A Multidimensional Coarse-Mesh Application for Advanced Reactor Thermal Hydraulics *A. J. Novak et al.*

Rattlesnake: A MOOSE-Based Multiphysics Multischeme Radiation Transport Application *Y. Wang et al.*

MASTODON: An Open-Source Software for Seismic Analysis and Risk Assessment of Critical Infrastructure *S. Veeraraghavan et al.*

Sockeye: A One-Dimensional, Two-Phase, Compressible Flow Heat Pipe Application *J. E. Hansel et al.*

Cardinal: A Lower-Length-Scale Multiphysics Simulator for Pebble-Bed Reactors *E. Merzari et al.*

Coupled Multiphysics Simulations of Heat Pipe Microreactors Using DireWolf *C. Matthews et al.*

What's cool about (your work in) nuclear thermal propulsion?

A fascination with space has been with me practically since birth. I grew up surrounded by planet-themed wallpaper, excessive Star Wars memorabilia, and Lego sets of NASA rockets and satellites on my desk. And so, it is exciting to see broad renewed interest in crewed space exploration missions as NASA pursues its journey to Mars framework. This ambitious scope of missions aims to send humans back to the moon and to the Red Planet for the first time, using a series of missions at each step to demonstrate mastery of the technologies developed for this program.

Challenges to enabling crewed missions continue to be reducing launch costs and limiting the exposure that astronauts receive from the space radiation environment. Nuclear thermal propulsion (NTP) is well positioned to tackle both of those constraints in the near term. NTP and its sister technology, nuclear electric propulsion, are both in-space propulsion systems that provide greater efficiency than chemical propulsion and much higher thrust than ion propulsion. NASA's recent partnering with the Department of Energy on the development of KRUSTY, the Kilopower surface fission reactor, shows how serious NASA is about developing nuclear technologies for the journey to Mars.

NTP has a wealth of experimental testing history from the NERVA [Nuclear Engine for Rocket Vehicle Application] program, which ran parallel to the Apollo program and the space race. While this data is valuable, modern core designs seek to mitigate proliferation concerns by replacing high-enriched uranium fuels with high-assay low-enriched uranium fuels. In addition, since funding for NTP research does not exist at the same vast scale as it did during NERVA, the most practical approach for modern design validation is to conduct both nuclear (in-pile) and nonnuclear (out-of-pile) experiments on NTP components at prototypic conditions.

Will Searight

Will Searight is a Ph.D. candidate in nuclear engineering at Pennsylvania State University.

The work in our lab is specifically focused on out-of-pile testing of NTP components in a hot hydrogen test loop, which can produce pressure and flow conditions like a single core channel, albeit at lower temperatures. Our design echoes that of successful NTP experimental facilities operating at NASA's Marshall Space Flight Center, which are central to NTP development, along with plans to make use of the Transient Reactor Test (TREAT) Facility at Idaho National Laboratory. Facilities like these will continue to be critical to establishing the real data necessary to prove that modern NTP designs will perform as expected and to provide the technology bedrock for sending people where they've never gone before.

RSCS
Radiation Safety & Control Services

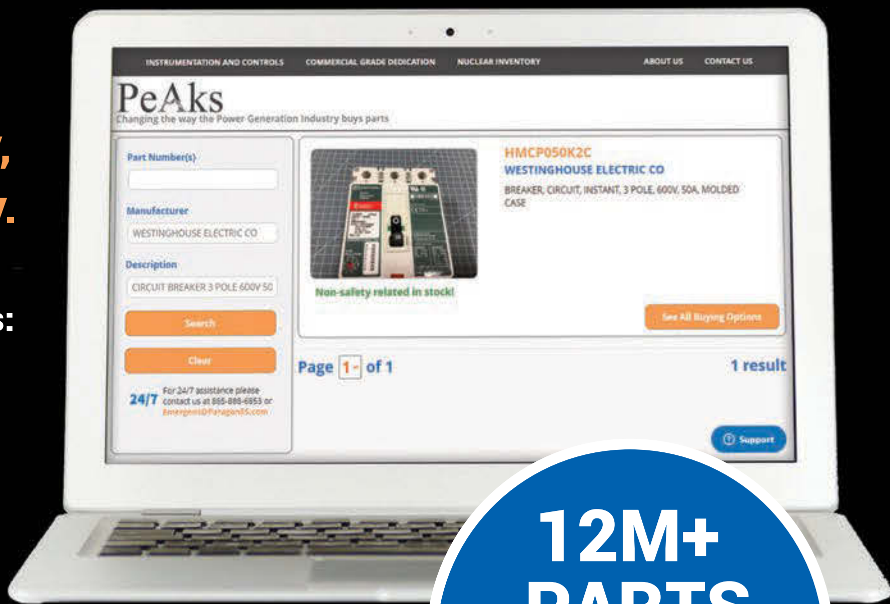
Your One Source for Professional & Technical Staff Augmentation

NUCLEAR | GOVERNMENT | INDUSTRIAL | MEDICAL | ACADEMIA

Tap into PeAks

a powerful, web-based catalog that matches power plant parts with buyers and sellers.

Linking buyers, suppliers and plants with needed and excess parts — quickly, easily, and cost-effectively.



What you need to know about PeAks:

- No login is required
- Available 24/7/365
- View on mobile, tablet or desktop
- Use in crisis situations, as a contingency plan, to lower costs, or for on-going parts sourcing
- Features U.S.-based customer service with years of experience supporting utilities

12M+ PARTS (and counting)
inventory updated weekly

PeAks

POWERED BY Paragon

The Nuclear Industry's Most Trusted Supplier

Give PeAks a test drive today:

https://catalog.paragones.com