Nuclear News

October 2020

In This Issue:

ATRC Upgrade: Idaho's ATR Critical Facility undergoes a digital control system upgrade

Ratliff and Harris: Innovation for safety and reliability

Robotics and Plant Maintenance

AMERICAN NUCLEAR SOCIETY


Westinghouse
PHOTO COURTESY OF JOSH ERNSTROM
COMMITTED TO YOUR OPERATING PLANTS
We Are Westinghouse – delivering innovation after innovation to improve plant efficiency, safety and cost-effective performance. From new and improved nuclear fuel to instrumentation and control, plant modifications to outage management, we deliver on our commitments, and have been doing so for more than 50 years.
westinghousenuclear.com
Westinghouse Electric Company
@WECNuclear
Westinghouse Electric Company
wecchinanuclear

October 2020 | Volume 63, Number 11

Focus on Robotics and Plant Maintenance

V1000 manipulator vehicle

Every Issue

On the Cover: Robotic arms were instrumental in improving operations at Sellafield. See page 48 for the full story.

Robots and nuclear

This issue of *Nuclear News* features an assortment of articles about robotics and remote systems used for nuclear activities. In that regard, robotics and remote systems have never been more relevant in the nuclear community. Nuclear decommissioning continues around the world, as the United States and countries such as Germany, Japan, South Korea, Ukraine, and the United Kingdom are all conducting research and development and deploying robotic systems in challenging environments to reduce the radiological, chemical, and thermal risk to humans.

At operating nuclear power plants, too, robotics and remote systems are used for tasks involving engineering, maintenance, and operations. Drones, for example, now fly above (and sometimes into) huge plant components for inspection purposes, eliminating the need to erect scaffolding for workers to reach high heights or tight spaces. Meanwhile, remotely operated submersibles now work in fuel pools, replacing the need to send human divers into high-dose areas for the job.

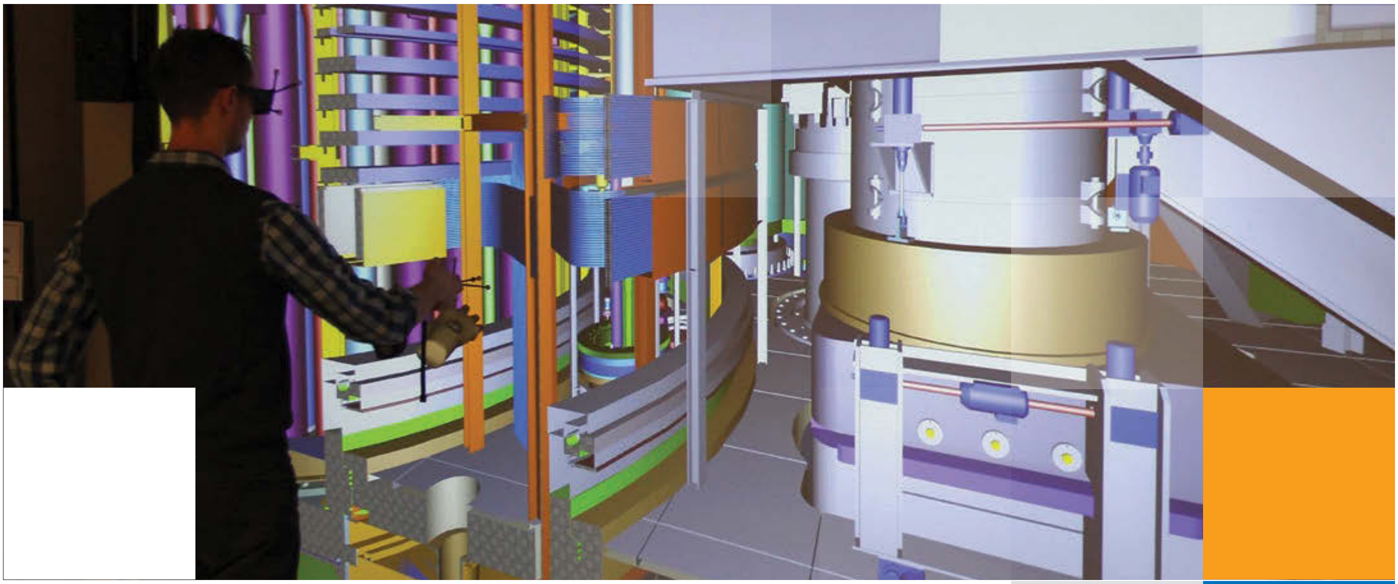
According to some industry experts, however, tasks such as turning valves on and off, navigating staircases, and moving over rough terrain can be problematic for automation. Will robots that can easily do these tasks show up one day at nuclear power plants? Opinions vary. Some say that creating robots that could walk up and down stairs, for example, might be overdesigning them. Others suggest that it's only a matter of time before robots that move like humans become the norm. The agreed-upon point is that human operators will always be needed to control the robots and remote systems.

If you're interested in robotics and aren't yet a member of ANS's Robotics and Remote Systems Division (RRSD), consider joining. The RRSD dates back to 1960, and it was ANS's first professional division. The original name, the Hot Laboratories Division, was changed to the Remote Systems Technology Division in 1965. To be more representative of its modern role, the current name was adopted in 1992. For decades its members have made significant contributions in all fields that use remote technology, including nuclear energy.

Today's RRSD is composed of more than 500 professionals from industry, government laboratories, and academia in the areas of automation, robotics, and remote systems. Areas of technical interest for RRSD members include mobile robots, industrial robots, manipulators, inspection and maintenance systems, reprocessing and fuel fabrication robotic units, computer vision, and artificial intelligence.

The division's mission is to promote the development and application of immersive simulation, robotics, and remote systems for hazardous environments for the purpose of reducing hazardous exposure to individuals, reducing environmental hazards, and reducing the cost of performing work.

Information about the RRSD and becoming a member is available on the ANS website at rrsd.ans.org.—*Rick Michal, editor-in-chief*



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
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 Mary Lou Dunzik-Gougar
Vice President/President-Elect Steven P. Nesbit
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
708/352-6611 • Fax 708/352-0499 • ans.org

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

***Nuclear News* Editorial**
708/579-8216 • Fax 708/579-8204
nucnews@ans.org • ans.org/nn

Nuclear News (ISSN: 0029-5574), Volume 63, Number 11. 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 2020 is $670, which includes complimentary electronic access, 1959 to current issue; for subscriptions outside North America, add $75 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.

Opinions expressed in this publication by the authors are their own and do not necessarily reflect the opinions of the editors, the American Nuclear Society, or the organizations with which the authors are affiliated, nor should publication of author viewpoints or identification of materials or products be construed as endorsement by this publication or by the Society.

Texts of most *Nuclear News* articles are available on the LexisNexis database, from Mead Data Corporation.

Comments on Conca

I read with interest James Conca's "Keeping nuclear plants running for 80 years trumps renewables and gas" in the September 2020 issue of *Nuclear News*, and I agree wholeheartedly with the conclusion that it is both safe and generally economic to extend the life of most U.S. nuclear plants to 80 years. In fact, many can be extended to 100-plus years (when the time comes for that evaluation).

However, there were a couple facts that were a bit off:

For the nuclear power plants being extended to 60 and 80 years, a better cost number to use is 3 cents/kWh, not the 4 cents/kWh quoted in the article (which makes license renewals even more economic). The cost-prohibitive plants are being retired—and these expensive plants raise the average to 4 cents/kWh.

Uneconomic plants do not survive, just like K-Mart and Sears—a basic principle of capitalism. In the United States, the nuclear plants in the most expensive quartile cost twice as much as those in the most economic operating quartile. Many things contribute to this wide disparity in cost, plant size being the foremost contributor.

The nuclear industry's "Deliver the Nuclear Promise" effort was embraced by many utilities to help reduce costs while maintaining (and sometimes enhancing) safety. Other utilities were late in embracing this concept or merely paid it lip service. Yes, "culling the herd" is painful, but what is left is cost-effective and safe.

Eric Hendrixson, PE
Ashland, Va.

More reader feedback

I received the July issue of *Nuclear News,* and I just loved it—the layout of the articles, the color, the white space, and the thicker paper. I am aware that white space and color are pricey, but I think *NN* will recoup the cost because advertisers will know that the magazine is being read. I hate to knock the old magazine, but I rarely just sat down and read it, because the layout and type were so dense that they were off-putting to me. I would read one article and maybe look up Vermont Yankee and Seabrook, and then I was done. I pretty much read this issue from cover to cover.

This is a great move! Between younger people who are used to reading on the Web and older people whose eyes rebel at small type, it was definitely time for this change.

The new ANS website is great, too.

Meredith Angwin
Wilder, Vt.

I looked and looked for Backscatter in the August issue. Now, reading the letters to the editor in the September issue, I have my answer.

I have been reading *Nuclear News* since getting out of the Army and returning to college 50 years ago. With the exception of a couple of misguided years in the late 1980s, I've been an ANS member since fall 1970.

Please restore some humor. Maybe Scott Adams could help. He is an engineer.

Robert E. Farrell
Broomfield, Colo.

A quick comment on the new format for *Nuclear News*. Overall, very nice, but it's hard to tell the difference between the ads and the articles. Also, for the photo captions, please make the print darker, or larger, or both. I have super-bionic replacement lenses in both eyes, and they're still hard to read.

Andrea Pepper
Decatur, Ga.

I want to let you know how much I like the new *Nuclear News*! I have made only a few trips to my office in the past few months, and I have found two issues of *NN* waiting for me. I like the larger font and the increased number of photos. Most of all, I like that *ANS News* has been incorporated into *NN*. Society news appears in other society magazines, and I think it belongs in *NN*.

It was great to see the new *NN* and great to read it.

Martin Grossbeck
Former chair, ANS Publications
Steering Committee
Knoxville, Tenn.

ATOMS

ROBOTICS TO THE TASK

First, identify a job in a high-radiation environment that needs doing, and then find (or build) a robot or system that can do the job. Whether the need is in plant maintenance, cleanup, assembly, inspections, surveying, or high-level waste management, robotics innovation is one way to save money, save time, and save dose.

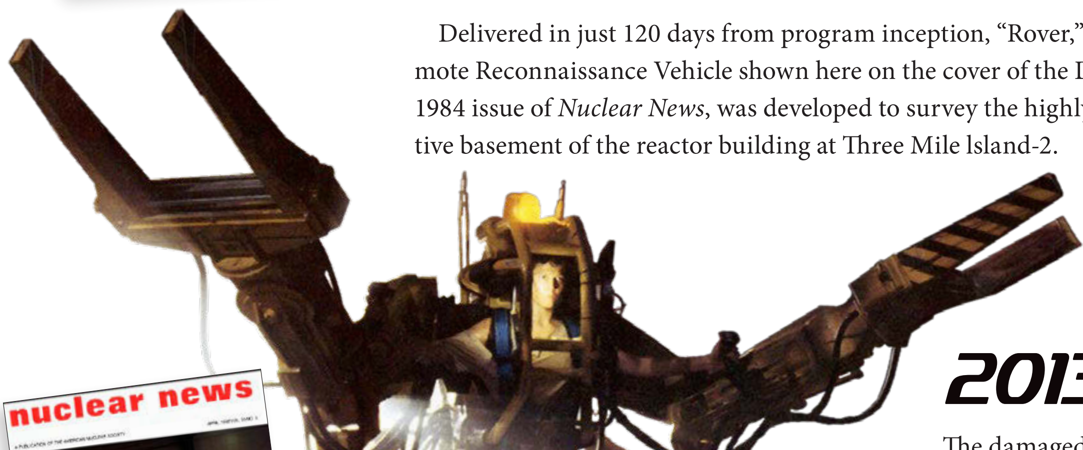
Here are just a few of the trends and achievements in robotics that have been recorded in *Nuclear News* over six decades.

1962: MEET THE BEETLE

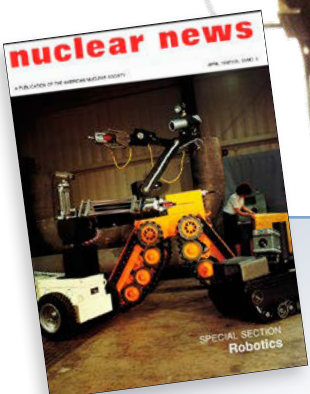
Heralded as a "tank-like, robot-like vehicle," and "an 85-ton giant with 16-foot arms that walks on tank treads, yet can pick up an egg with the touch of a child," the Beetle was introduced in the March 1962 issue of *Nuclear News*. Developed by General Electric for the U.S. Air Force, it carried an operator inside a cab with foot-thick lead shielding and was originally meant to service a fleet of nuclear aircraft—a program that never took off. The Beetle was completed, however, and was sent to the Air Force Special Weapons Center for work on the Rover nuclear rocket program.

1984: ROVER TO THE RESCUE

Delivered in just 120 days from program inception, "Rover," the Remote Reconnaissance Vehicle shown here on the cover of the December 1984 issue of *Nuclear News*, was developed to survey the highly radioactive basement of the reactor building at Three Mile Island-2.



(Image ©1986 Twentieth Century Fox Film Corp. All rights reserved.)

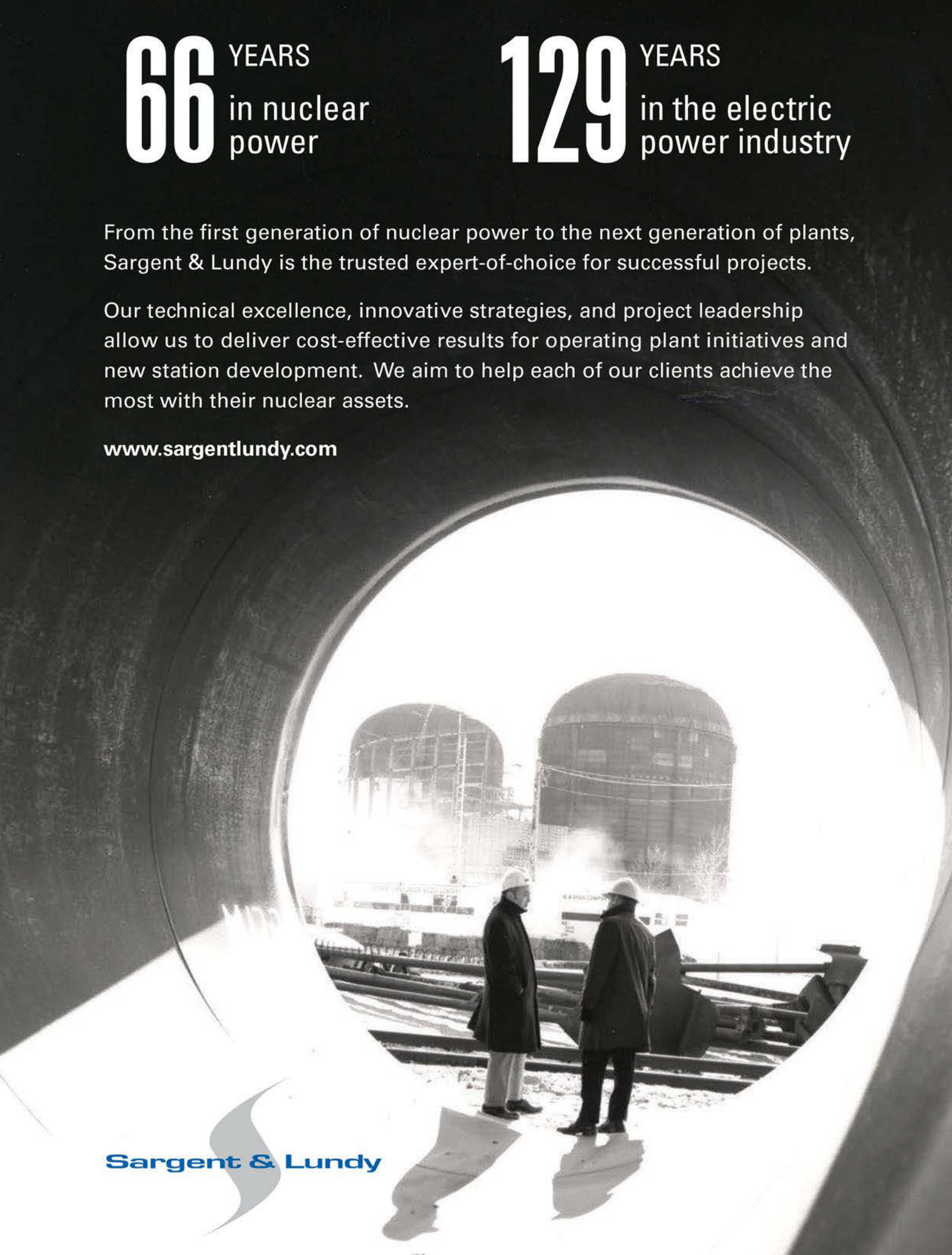


1992: "YOU AIN'T SEEN NOTHING YET"

A comprehensive survey of robotics in the April 1992 issue of *Nuclear News* introduced readers to Harry T. Roman, then principal engineer for PSE&G's robotics and artificial intelligence program. Roman took inspiration for the idea of a strength-amplifying exoskeleton robotic system for plant workers from Sigourney Weaver's wielding of the Power Loader in the 1986 film *Aliens*. Reflecting on the future of robotics, Roman said, "When somebody asks me about the state of the technology, I generally tell them, 'You ain't seen nothing yet—this stuff is going to go wild.'"

2013: REACHING NEW HEIGHTS

The damaged Fukushima Daiichi reactors in Japan posed new challenges for robotics technology and marked the first time that commercial off-the-shelf, semiautonomous ground robots were used in response to a large-scale nuclear power plant emergency. A High-Access Survey Robot, shown here on the cover of the December 2013 issue (bottom right), was custom designed in Japan to reach heights of 7 meters and access high-ceilinged areas of the reactor buildings.


66 YEARS in nuclear power
129 YEARS in the electric power industry
From the first generation of nuclear power to the next generation of plants, Sargent & Lundy is the trusted expert-of-choice for successful projects.
Our technical excellence, innovative strategies, and project leadership allow us to deliver cost-effective results for operating plant initiatives and new station development. We aim to help each of our clients achieve the most with their nuclear assets.
www.sargentlundy.com
Sargent & Lundy

Despite current policy and economic challenges, nuclear's future remains bright

By Bryan Hanson

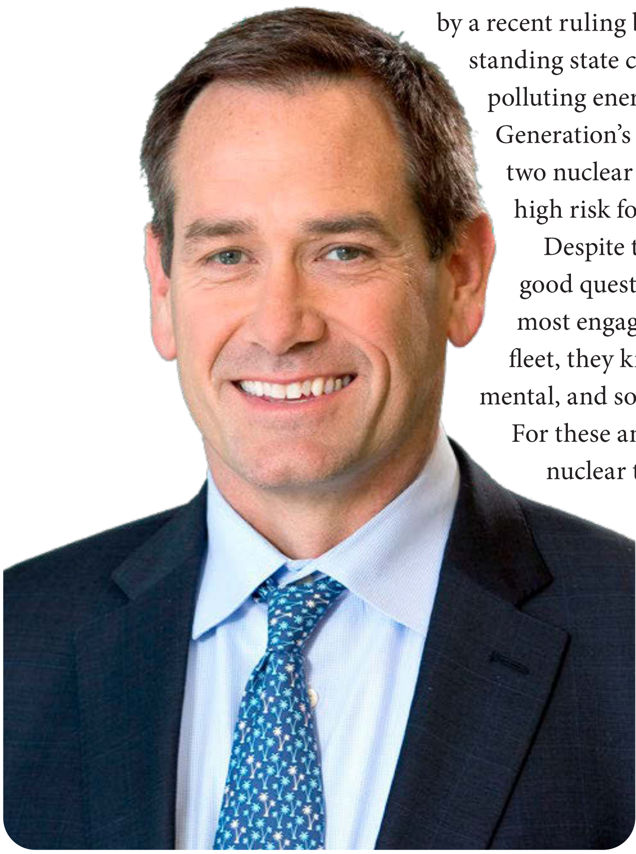
On August 27, I stood in front of small groups of socially distanced employees at our Dresden Generating Station in Illinois, announcing plans for the premature retirement of the nuclear facility next fall. A hundred miles away, our chief operating officer was delivering a similar, equally somber announcement to employees at the Byron Station.

Despite being among the safest, most efficient, and reliable nuclear plants in the nation, Dresden and Byron face revenue shortfalls in the hundreds of millions of dollars because of declining energy prices and market rules that allow fossil fuel plants to underbid clean merchant nuclear resources in the PJM capacity auction, even though there is broad public support for sustaining and expanding clean energy resources to address the climate crisis.

As we said in our announcement, the plants' economic challenges were further exacerbated by a recent ruling by the Federal Energy Regulatory Commission that undermines long-standing state clean energy programs and gives an additional competitive advantage to polluting energy sources in the auction. Sadly, as a result of these market rules, Exelon Generation's LaSalle and Braidwood nuclear stations in Illinois, each of which house two nuclear units and together employ more than 1,500 skilled workers, are also at high risk for premature closure.

Despite the sad news, our Dresden and Byron employees listened intently, asked good questions, processed the information, and went back to work. As some of the most engaged and high-performing employees in the Exelon Generation nuclear fleet, they know that nuclear is vital to the country's ambitious economic, environmental, and social equity goals.

For these and other reasons, we remain hopeful. We know there's no match for nuclear technology in the global fight against the climate crisis, and there have been a slew of exciting developments recently to justify our optimism.



Bryan Hanson, executive vice president and chief generation officer, Exelon Generation

In August, TerraPower launched its "cost-competitive sodium fast reactor combined with a molten salt energy storage system." On August 28, the U.S. Nuclear Regulatory Commission completed the technical review of the design certification application for NuScale's groundbreaking small modular reactor with the issuance of the final safety evaluation report. These are exciting developments for the industry that should be recognized.

And, amid the many challenges of COVID-19, U.S. nuclear plants have delivered outstanding reliability and flexibility, powering hospitals and treatment facilities 24/7 while protecting plant workers and host communities, even during refueling outages.


Photo: Exelon


Photo: NRC

Photo: NuScale


Photo: TerraPower

Byron (top left) and Dresden (top right) may be looking at early retirement, but new technologies like NuScale's SMR (bottom left) and TerraPower's Natrium (bottom right) show a bright future ahead for nuclear.

We executed several record-setting outages this spring that set the stage for a summer capacity factor of over 97 percent. Our average duration for the spring outages clocked in at 17 days, a full two weeks shorter than the national average. This efficiency alone generated carbon-free power for an additional 4.6 million homes, hospitals, and other essential businesses during a critical time. We continue to make our nuclear facilities even safer, more effective, and cost-efficient than ever before, reinforcing nuclear's enormous value. All while minimizing the spread of contagions for our communities, employees, and families.

America's nuclear plants continue to set the bar higher year over year for safety, reliability, and operational excellence, while driving costs down. Across the industry, we've identified hundreds of millions of dollars in efficiencies to cut total costs by an average of 25 percent, according to a Nuclear Energy Institute study from 2019. This is a far cry from my early days at the Quad Cities station, where we thought that refueling outages lasting fewer than 100 days were a stretch and that maintenance budgets of less than $100 million were impossible to improve reliability.

With these innovations and industry improvements as a backdrop, many state and federal policymakers on both sides of the aisle are starting to understand, engage, and espouse the value of nuclear power. The Nuclear Powers America Act is a great example of bipartisan support to get nuclear energy recognized for its clean air contributions.

I have a long-term positive outlook for our industry. For our short-term challenges, we will need the full force of our nuclear professionals and supporters. After the Byron and Dresden announcement, one of the top questions I received was, "How can I help?" In addition to focusing on operating all nuclear plants at top levels of operational excellence, we need everyone to yell from the top of every hill about the importance of carbon-free nuclear energy. Our climate is depending on us.

Spotlight On . . .

The ANS/ASME

Joint Committee on Nuclear Risk Management

The Joint Committee on Nuclear Risk Management (JCNRM) was formed in 2011 by the merger of the American Nuclear Society's Risk Informed Standards Committee (RISC) and the American Society of Mechanical Engineers' (ASME) Committee on Nuclear Risk Management (CNRM).

Before the merger, the RISC and the CNRM collaborated to harmonize the two societies' work on probabilistic risk assessment (PRA) standards. The merger improved coordination and made better use of volunteer resources.

The JCNRM is responsible for the preparation and maintenance of voluntary consensus standards that establish safety and risk criteria and methods for completion of PRA and other risk assessments.

Additional related standards activities may be performed upon concurrence of the ANS Standards Board and the ASME Standards & Certification Board. These criteria and methods are applicable to design, development, construction, operation, decontamination, decommissioning, waste management, and environmental restoration for nuclear facilities.

Activities of the JCNRM are guided by the Procedures for ASME's Codes and Standards Development Committees, but these activities also meet the intent of the ANS Standards Committee Procedures Manual for Consensus Committees unless specifically authorized by the ANS Standards Board.

The JCNRM oversees the following three subcommittees:

- Subcommittee on Standards Maintenance (SC-SM)
- Subcommittee on Standards Development (SC-SD)
- Subcommittee on Risk Applications (SCoRA)

The flagship standard for the JCNRM is: ANSI/ASME/ANS RA-S-2008 (R2019), *Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications*. It was issued in 2008 as a RISC/CNRM collaborative work. The RISC/CNRM called this the "combined standard" because it combined ASME RA-S-2002, *Standard for Probabilistic Risk Assessment for Nuclear Power Plant Applications*, issued by ASME, with ANS-58.21-2007, *External-Events PRA Methodology*, and ANS-58.23-2007, *Fire PRA Methodology*, issued by ANS. Few to no changes were made to these standards when combined.

Immediately upon issuing the combined standard in 2008, the JCNRM initiated a revision to update the standard and to improve its consistency throughout. Addendum A and Addendum B, issued in 2009 and 2013, respectively, were the products of this effort.

While ASME/ANS RA-S is the flagship standard, the JCNRM has a number of other standards products in development. A status report of all JCNRM projects, including an update on ASME/ANS RA-S, is provided below:

ASME/ANS RA-S-1.1, *Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications*

Work on the next edition of this standard, the Level 1/Large Early Release Frequency (LERF) PRA standard, was initiated immediately upon approval of Addendum B (of RA-S) in 2013. A Code Case for Part 5 (seismic PRA) was published in November 2017. This next edition will be designated RA-S-1.1.

The revision will contain many substantive changes based on feedback from recent users of the standard along with extensive reformatting and the like and including elimination of Capability Category III. Extensive efforts are being made to improve consistency in requirements, terminology, and clarity.

The Part 5 Code Case already reflects many of the features of the next edition of RA-S. In addition, Parts 7 (high winds), 8 (external flood), and 9 (other hazards) are being completely replaced to reflect almost 20 years of additional experience.

Finally, Part 10 (seismic margins assessment) has been deemed inappropriate for a PRA standard and is being deleted.

The next edition of the Level 1/LERF PRA standard was issued for a review and comment ballot in the summer of 2018, resulting in more than 2000 comments. As of the first quarter of 2019, all comments had been addressed; however, there were still concerns about consistency. While the working groups together addressed the most straightforward of these consistency issues, a few issues continued to create significant friction between different interest groups. A series of industry/Nuclear Regulatory Commission workshops, which extended well into 2019, were held to develop input to the working groups on how those parties would like to see these issues resolved. Their comments were addressed (most accepted, but not all), and the revised version was issued for ballot in December 2019. The standard is expected to enter the editing/publication process in the fourth quarter of 2020.

The JCNRM is composed of more than 100 volunteers. Individuals interested in joining the JCNRM may find information and required documents by clicking on the Codes & Standards menu item at asme.org.

Individuals interested in volunteering in the ANS standards process may find information by clicking on the Get Involved menu item at ans.org/standards.

All ANS standards are available for purchase at techstreet.com/ans.

Spotlight On continues

Table A: ANS/ASME-58.22 Trial Uses Completed or Under Way, March 2015 through six months after approval of the next edition of RA-S

Application	User	Time Frame
Application to Palo Verde Nuclear Power Station	Arizona Public Service (APS)	February 2015
Self-assessment of APS pilot application	Electric Power Research Institute	March 2015
Exelon/Boiling Water Reactor Owners' Group (BWROG) test of qualitative-risk portion	Exelon/BWROG	2016–2017
BWROG pilot of quantitative portion	BWROG	2016–2017
United Kingdom Advanced Boiling Water Reactor pilot	GE Hitachi (GEH)	2016
LPSD portion of NRC Level 3 PRA pilot	NRC	Feedback 2017
AP1000 trial of qualitative portion	Westinghouse	Feedback 2017
Korean trial use	Korea Hydro & Nuclear Power	Undefined

ANS/ASME-58.22, Requirements for Low Power and Shutdown Probabilistic Risk Assessment

ANS/ASME-58.22-2014, the low power and shutdown (LPSD) PRA standard, was issued for a trial-use period in March 2015. A summary of trial uses completed or under way is provided in Table A. Feedback from these parallel trial-use applications is being considered. Currently, at-initiator human actions are being revised, and 75 percent of the comments regarding the qualitative sections have been resolved. The trial-use period was extended until six months after the approval of the next edition of ANS/ASME-RA-S to ensure that the standards align. Once finalized, the LPSD PRA draft standard will be issued for ballot with the intent of seeking approval by the American National Standards Institute (ANSI).

ASME/ANS RA-S-1.2-2014, *Severe Accident Progression and Radiological Release (Level 2) PRA Standard for Nuclear Power Plant Applications for Light Water Reactors (LWRs)* (previously ANS/ASME-58.24)

This standard, the Level 2 PRA standard, was issued in January 2015 for trial use. An initial trial use was performed on the Level 2 portion along with the NRC Level 3 PRA pilot study by the Pressurized Water Reactors Owners' Group (PWROG). An additional pilot and feedback was also provided by GE Hitachi Nuclear Energy (GEH) as part of its United Kingdom Advanced Boiling Water Reactor (UK ABWR) PRA. Feedback has been considered in developing the final draft version, which was issued for a two-month review and approval ballot to the JCNRM in November 2019. The ballot closed with a few negatives and a significant number of comments. The working group will be addressing these comments soon prior to revising the draft for a final ballot.

ASME/ANS RA-S-1.3, *Standard for Radiological Accident Offsite Consequence Analysis (Level 3 PRA) to Support Nuclear Installation Applications* (previously ANS/ASME-58.25)

This standard, the Level 3 PRA standard, was issued in July 2017. A trial-use application, based on the balloted version, was performed in December 2015 by the PWROG in support of the Level 3 portion of the NRC Level 3 PRA pilot. GEH has also provided trial-use feedback from its UK ABWR PRA pilot, and additional feedback has been received as part of the trial-use feedback on the non-light-water reactor (NLWR) PRA trial-use standard (RA-S-1.4). The working group's current focus is to align this standard with the next edition of the Level 1/LERF PRA standard (RA-S-1.1), which is currently addressing final comments.

ASME/ANS RA-S-1.4-2013, *Probabilistic Risk Assessment Standard for Advanced Non-LWR Nuclear Power Plants*

This standard, the NLWR PRA standard, was approved for trial use and issued in December 2013. Several potential pilot applications have been performed internationally (see Table B). The working group has been actively engaged with trial users representing several advanced reactor design concepts in various stages of design in the United States, China, South Korea, and the United Kingdom.

In September 2019, the JCNRM decided to decouple the NLWR PRA standard from the next edition of the Level 1/LERF PRA standard (RA-S-1.1) to ensure that it should be available by the end of 2020 to support regulatory applications. The NLWR PRA standard has been approved and is currently in production.

Table B: ASME/ANS RA-S-1.4-2013 Trial Uses Completed or Under Way, December 2013 through six months after approval of the next edition of RA-S

Application	User	Time Frame
High-temperature pebble bed reactor	China	2007–2019
Korea Atomic Energy Research Institute/Argonne National Laboratory (ANL) sodium-cooled fast reactor	ANL	Ended
Traveling wave reactor/ sodium-cooled fast reactor	TerraPower	On hold
Molten chloride fast reactor	TerraPower	Ongoing
General Electric PRISM sodium-cooled fast reactor	GEH	License Modernization Project (LMP) trial
Xe-100 pebble bed advanced reactor	X-Energy/ SNC-Lavalin	Ongoing
Japan high-temperature gas-cooled reactor PRA	Japan Atomic Energy Agency (JAEA)	Pilot done
Japan liquid-metal fast breeder reactor PRA	JAEA	2016–2020
Fluoride salt-cooled high-temperature reactor	Kairos Power	LMP
Oklo	Oklo Inc.	LMP
eVinci micro reactor	Westinghouse	LMP
Versatile test reactor	Westinghouse	Just starting
Lead fast reactor	ANL/GEH	2019–2020
China sodium-cooled fast reactor	ANL	On hold

ASME/ANS RA-S-1.5, *Advanced Light Water Reactor PRA Standard*

The advanced LWR (ALWR) PRA standard, RA-S-1.5, was planned to be balloted starting in September 2013 but has been delayed several times to accommodate changes in scope—i.e., to engage light-water small modular reactor vendors to ensure that the standard would address their needs, and also to accommodate significant changes requested by the NRC to accommodate its intended application of the standard to the new plant licensing process. A ballot on this standard for trial use was held in the fourth quarter of 2017, but a number of comments were received regarding the need for a clear definition of large release that will be compatible across the JCNRM standards. A ballot on the large release definition was initiated in late 2018, and a reconsideration ballot on the ALWR PRA standard was issued in the first quarter of 2019 and then again in September 2019. In 2020, the main focus of the working group has been to align this standard with the next edition of the Level 1/LERF PRA standard (RA-S-1.1). The ALWR appendix will be issued initially for a three-year trial use once approved.

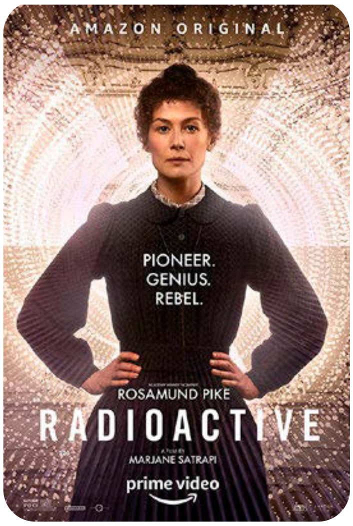
ASME/ANS RA-S-1.7, *Standard for Multi-Unit PRA*

The writing group for the Multi-Unit PRA (MUPRA) standard was organized in mid-2019. Its work is in its early stages, although it is building upon significant work performed by an earlier JCNRM writing group that prepared a MUPRA appendix to the Level 1/LERF PRA standard (RA-S-1.1). The material in that draft appendix will be expanded and coordinated with the Level 1/LERF PRA standard (RA-S-1.1). The MUPRA standard will be issued as a stand-alone standard for trial use. No schedule is available at this time.

Melodrama trumps science in *Radioactive* portrayal of Marie Curie

By Susan Gallier, *NN* staff writer

Marie Curie has been quoted as saying, "Nothing in life is to be feared, it is only to be understood." We can only wish that the creators of *Radioactive*, a feature-length biopic released on Amazon Prime Video on July 24, had increased their own understanding of the applications of nuclear technology before making the film. While celebrating Curie as an uncompromising woman of science, they present a curious mix of respect and fear, explicitly linking radiation and nuclear technology to death and destruction.



Amazon bills the film as "a bold, visionary depiction" and "an exploration of the transformative effects of how Curie's work has impacted the defining moments of the 20th century." The dual aims—depicting Curie's life and linking her to events that occurred decades after her death—strain plausibility and invite the viewer to share the filmmakers' ambivalence about the legacy of Curie's work.

The film is based on a graphic novel, published in 2010, by Lauren Redniss. The film adaptation was directed by Marjane Satrapi, herself the graphic novelist behind the book *Persepolis*. The score of *Radioactive*, largely set in a minor key and punctuated with sonar pings and a fire engine's wail, creates a sonic atmosphere of otherworldly emergency that amplifies the effect of the striking and at times fanciful cinematography.

Fact vs. fiction

When it comes to the science, viewers will hear several short statements of fact with the bland accuracy of a middle-school textbook. Yet the accuracy of some statements should not lull the viewer into believing that the picture is an accurate representation of the life of the first woman to receive a Nobel Prize, and the only person to receive a Nobel Prize in both physics and chemistry.

The film's landing page on Amazon Prime proclaims that it is "the incredible, true story of Marie Curie and her Nobel Prize–winning work that changed the world." Amazon offers a link to lesson plans for teachers developed for release with the film but does not repeat that claim of truth, stating, "*Radioactive* is a biopic and not a nonfiction biography. A biopic is a dramatization of the real-life events of a person's life. The writer, director, and actors in *Radioactive* use artistic license to interpret Marie

Curie's story—including the timeline, events, and characterizations of people represented in the film."

To Amazon's credit, the lesson plans direct teachers to balanced, reputable sources for more information. In fact, a lesson plan on science and scientific inquiry points teachers to Navigating Nuclear, the K–12 education program developed by the American Nuclear Society in cooperation with Discovery Education.

Flash forward

The film opens with Curie, played by Rosamund Pike (from the movie *Gone Girl*), collapsing as she begins a day's work in her laboratory at age 66. As she is taken to a hospital, near death, the film cuts to flashbacks of Curie's first days as a student in Paris in the 1890s. Flashbacks—and their back-to-the-future twin, flash forwards—free the filmmakers from the constraints of time, and their juxtaposition with scenes from Curie's work in the lab shapes the narrative. Occasional dream sequences permit more artistic license.

The film uses flash forwards to link Marie and Pierre Curie's discoveries to nuclear technologies developed decades later, and images of disaster, destruction, and fear suggest that blame, not credit, is being assigned to the pair.

As the film portrays Pierre Curie (played by Sam Riley) delivering a lecture after he, Marie Curie, and Henri Becquerel were awarded the 1903 Nobel Prize in Physics, stylized scenes dramatizing the dropping of Little Boy on Hiroshima in 1945 are interposed with a speech in which Pierre declares, "I am one of those who believe, with Nobel, that mankind will derive more good than harm from these discoveries."

A depiction of the Chernobyl accident in 1986 intersects with shots of a personal "meltdown" as Marie Curie struggles with grief and the burden of press scrutiny after the death of her husband, Pierre.

One of the more fantastical sequences in the film begins with Marie Curie standing at the front of a lecture hall at the Sorbonne. "I want to tell you about radium," she says to her students. "It does not behave as it should." The film then cuts to Nevada in 1961 for a dramatized nuclear bomb test, and viewers watch a family of mannequins melt into the ground as their elaborate "doom town" is destroyed in the blast (which, incidentally, would not have used radium). Frequent cuts between the test site and Curie in Paris, caring for her daughters and working

A still image from *Radioactive* shows Rosamund Pike as Marie Curie at work in her lab.

in her lab, suggest she was careless, indifferent, or complicit. Before the bomb explodes, for example, we see Curie set up equipment in her lab that suddenly releases small amounts of pressurized gas and liquid, causing Curie to exclaim "Oh no, no, no!" before she mutters to her colleagues, "Sorry everyone. I do apologize."

Even while the film acknowledges the therapeutic tools of nuclear medicine, the choice of imagery engenders fear and mistrust. After Pierre Curie says, with fervor, "I can feel our work glowing out. I can feel it changing the world," a flash forward takes us not to the precision treatments of today but to 1957 as a wary young boy is strapped down in front of a linear accelerator for experimental cancer treatment.

Woman, scientist, and mother

Making the film's grim perception of radiation explicit, Curie is depicted advising her daughter Irène (who would go on to win a Nobel Prize with her husband, Frédéric Joliot-Curie) to abandon a career in science.

"As exciting as it seems, radiation is not safe,"

A Critical Look continues

Pike's Curie is outspoken and unapologetic, a striking contrast to the woman described as "quiet, dignified, and unassuming" in a biographical account from the Nobel Prize organization.

says Curie, as played by Pike, before going on to say that she had spent her entire life "surrounded by death and radiation". . . and "they've brought me very little happiness. I want better for you." Given that mother and daughter collaborated in the lab for years, it's probably safe to say that those words belong to the filmmakers, not Curie.

Radioactive does not shy away from mentioning the xenophobic and sexist treatment Curie received following press accounts of her affair with physicist Paul Langevin four years after her husband's death. While celebrating the self-assurance with which Curie conducted her life and work, and arguably presenting a fuller portrait of a woman who could be passionate about more than science, the filmmakers may once again be taking artistic liberties. Pike's Curie is outspoken and unapologetic, a striking contrast to the woman described as "quiet, dignified, and unassuming" in a biographical account from the Nobel Prize organization. While Curie was undoubtedly bold and determined in the laboratory, have the makers of *Radioactive* applied 21st-century assumptions of what it means to be a bold, assertive woman to Curie, with anachronistic results?

From the golden age of Hollywood

Greer Garson was nominated for a best actress Oscar for a markedly different portrayal of Marie Curie in the 1943 film *Madame Curie*, based on the book of the same title by Curie's daughter Ève. Garson's Curie is a young woman who loves "physics and mathematics and Poland," and who, while a driven scientist, is unfailingly polite, whether at tea parties or standing before the French Academy of Sciences.

While *Madame Curie* avoids any whiff of scandal and downplays the symptoms of radiation exposure suffered by the Curies, it gives much more time to science than does *Radioactive*. Take, for example, Curie's recognition that pitchblende must contain an unknown element with more radioactivity than two of its known constituents, uranium and thorium. In *Radioactive*, that realization, which set the Curies on an arduous four-year process to isolate tiny quantities of polonium and radium from four tons of pitchblende, is portrayed in just over one minute, with about two more minutes given to an explanation of the process. *Madame Curie*, by contrast, takes the viewer on a trip to Becquerel's lab to view his photographic plates *in situ* before devoting a full nine minutes to Curie's process of deduction in a fascinating glimpse of 19th-century science in action.

Together, the two films will frustrate a viewer looking for the truth about Curie's life. Accepting that both films take license with the details, the contradictions leave us to wonder: Just how did Pierre and Marie meet and decide to marry? Did Marie need Pierre's encouragement, as in *Madame Curie*, or was she entirely self-driven, as in *Radioactive*? Did the pair struggle with four tons of pitchblende by themselves, or did they share that labor with assistants? Did Marie Curie speak before all-male panels of academicians with defiance or with restrained courtesy? After watching either film, the viewer will likely want to turn to an authoritative biography for answers.

ANS designates TFTR and FCF for landmark status

The Tokamak Fusion Test Reactor (TFTR) at Princeton University and the Fuel Cycle Facility (FCF) (now known as the Fuel Conditioning Facility) at Idaho National Laboratory have been designated as ANS Nuclear Historic Landmarks. The official awarding of the honors will occur during the 2020 ANS Virtual Winter Meeting, which begins November 16.

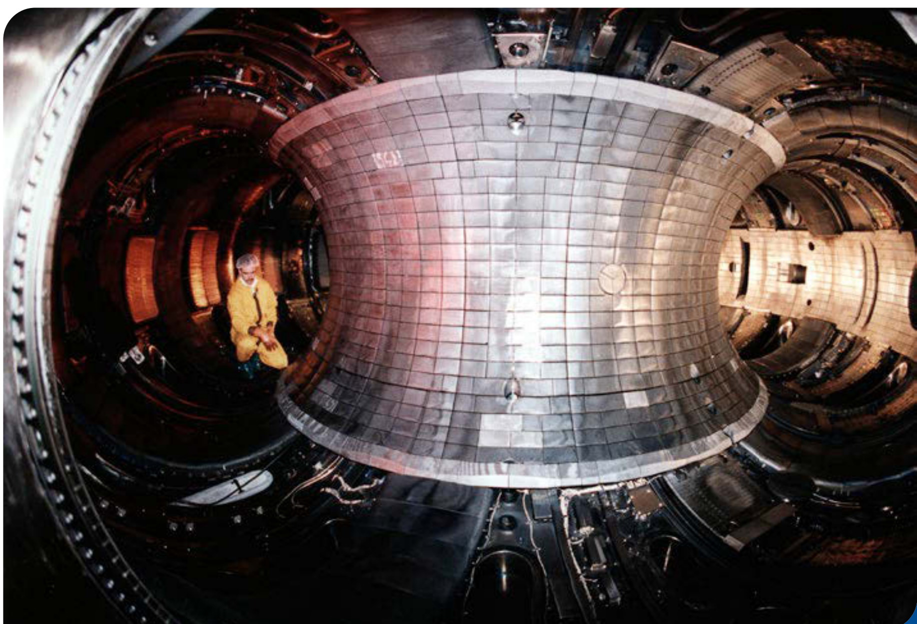
The TFTR received the award for demonstrating significant fusion energy production and tritium technologies for future nuclear fusion power plants and for the first detailed exploration of magnetically confined deuterium-tritium (D-T) fusion plasmas.

INL's FCF and its Experimental Breeder Reactor II (EBR-II) were honored for demonstrating on-site recycling of used nuclear fuel back into a nuclear reactor.

The TFTR project was initiated in 1976. The facility went into operation in December 1982 and spent the next decade using weakly reacting deuterium fusion fuel to develop, understand, and achieve the plasma conditions, full performance of the tokamak, plasma heating systems, and plasma diagnostic systems required for the D-T mission. In 1993, it began the first magnetically confined fusion experiments using a 50:50 mix of deuterium and tritium, the fuel envisioned for future fusion power plants.

"For those of us who participated in the deuterium-tritium experiments, it was a once-in-a-lifetime opportunity filled with challenges in demonstrating significant fusion energy and the excitement of extending the frontier of fusion research to near fusion plasma conditions," said Rich Hawryluk, former head of the TFTR project and currently associate director for fusion at Princeton Plasma Physics Laboratory. "We are very grateful to the American Nuclear Society for the Nuclear Landmark Award in recognition of the role that the deuterium-tritium experiments on the Tokamak Fusion Test Reactor played in the development of fusion energy. This was a laboratory-wide scientific and technical undertaking that involved national and international collaborators, who played a major role in all aspects of the experiment as well as the support and engagement of the U.S. Department of Energy."

A look inside the TFTR plasma vessel. Photo: DOE



Among the various scientific achievements generated through more than 1,000 D-T experiments was the first detailed study of the behavior of the alpha particles produced in the D-T fusion reaction that are critical in sustaining the fusion

Nuclear Trending continues

The EBR-II and Fuel Cycle Facility at INL. Photo: INL

reaction in a fusion power plant.

In the 1960s, FCF was constructed as part of the EBR-II project at the Argonne National Laboratory–West site (now a part of INL). FCF demonstrated that spent, highly enriched uranium fuel could be remotely processed to recover the uranium, with the uranium recycled and remotely fabricated into new fuel to be returned to the reactor. The recycle process demonstrated in FCF was a low-decontamination, on-site, melt-refining process, based on work with uranium and plutonium separations initially performed in the Manhattan Project.

"All of us at INL are grateful to ANS for this important recognition, not just of the Fuel Cycle Facility, but those who worked inside it," said INL Director Mark Peters. "The original FCF designers and operators accomplished something special, demonstrating the potential for fast reactors with the ability to recycle fuel. This is an important part of INL's legacy. We are proud of all they accomplished and remain determined to continue building on their important work."

The Nuclear Historic Landmark Award identifies and memorializes sites or facilities where outstanding physical accomplishments took place that were instrumental in the advancement and implementation of nuclear technology and the peaceful uses of nuclear energy. The award recognizes facilities that were placed in service 20 or more years ago. The designation of these sites is symbolized by an engraved bronze plaque for display at or near the original site. Each plaque is presented by an official representative of ANS at an appropriate ceremony.

Nuclear Notables—October

1957 The Windscale fire, the United Kingdom's most serious nuclear accident, occurs.

1963 The Limited Nuclear Test Ban Treaty enters into force after being signed by the United States, Britain, and the Soviet Union in August.

2016 The Tennessee Valley Authority's Watts Bar-2 enters commercial operation.

1940 1950 1960 1970 2010 2020

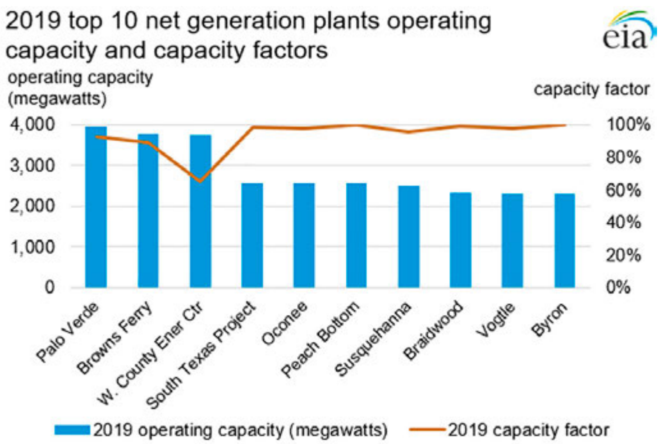
1945 The French Atomic Energy Commission (Commissariat à l'Énergie Atomique), the first civilian government agency for nuclear power, is established.

1968 Lise Meitner, the Austrian-Swedish physicist who contributed to the discovery of protactinium and nuclear fission, died on October 27.

The cost of unreliability

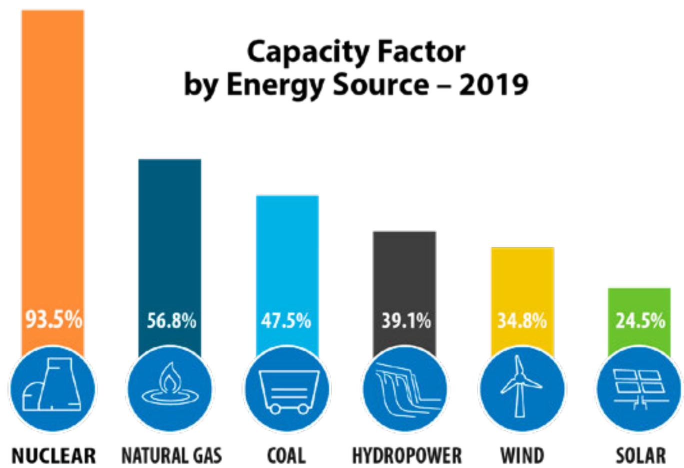
In the September issue of *Nuclear News*, I asked if you've ever wondered why nuclear isn't commonly considered *the* choice for clean power production. In that column and in August's, I provided some information about the cleanliness and safety of nuclear for your use as you make the case for this clean energy source to friends and neighbors. This month, let's talk reliability.

In power, one of the best measures of reliability is capacity factor. It's no surprise that nuclear power plants consistently make the list of the top 10 net generation plants, per the Energy Information Administration, with plant capacity factors at or close to 100 percent. In 2019, nine of the 10 plants listed were nuclear, and all of those had higher capacity factors than the tenth plant, which is a natural gas facility.



To be fair, nuclear power plants generally are operated at full power for an extended period, whereas coal plants are now operated mostly in load-following mode due to competition from natural gas. Before the onset of this recent era of cheap natural gas, coal power plants regularly populated the top 10 list. We mustn't forget, and appreciate, that coal powered the Industrial Revolution and the vast increase in standard of living that we enjoy today. Even when operated as baseload plants, however, neither gas nor coal plants are as reliable as nuclear due to their higher frequency of routine maintenance and refueling. Given today's global interest in limiting carbon emissions, let's set aside consideration of fossil plants and compare reliabilities of only nonemitting power sources.

The so-called renewable sources of energy—hydro, wind, and solar—are by their nature intermittent and therefore considered inherently unreliable, mostly limited by lack of "fuel." Indeed, these plants require backup power that is supplied by fossil and nuclear. Currently, only 3 percent of worldwide electricity comes from wind and solar, despite billions of dollars in subsidies and decades of development. Alex Epstein, president and founder of the Center for Industrial Progress, refers to renewables as "unreliables." Do you believe that a modern industrial economy, and the standard of living that it creates, can be sustained by power sources that are



ANS President's Column continues

ANS President's Column continues

available less than one-third of the time they are needed—and on an unpredictable schedule?

For decades, the costs of coal and natural gas have been decreasing and the cost of uranium has stayed relatively low. Despite the low fuel costs, the overall cost of electricity has increased. Why? The reason is the forced increase in the use of unreliable wind and solar. In the United States, renewable portfolio standards (requiring some percentage of renewables in a given region) and feedthrough tariffs (guaranteeing above-market-price rates for renewable feed to the grid) raise the cost to the consumer. Look overseas for an example: In Germany, the cost of electricity almost doubled from 2000 to 2016 due to the increased deployment of renewables, which accounted for about 34 percent of generation in 2019. Meanwhile, half of German electricity is still produced by burning fossil fuels, and nuclear plants are being systematically shut down.

The moral of the story here is that reliable, plentiful electricity enables and sustains a modern (clean, safe, prosperous, *and* enjoyable) life. Without it, people will be poor, with low quality of life and shorter life expectancy. Increased deployment of renewables, while nonemitting, decreases reliability and increases the cost of electricity and all the things we rely on that also use electricity (like food production). The result? More poor people—rather than fewer—a backward move for humanity.

Next month, I will discuss the "scalable" aspect of nuclear. Cheers!—*Mary Lou Dunzik-Gougar (president@ans.org)*

Calling balls and strikes

As a not-for-profit scientific and professional organization, the American Nuclear Society's *raison d'être* has always been the advancement of nuclear science and technology. While many among our diverse ranks may see themselves as advocates, it is important to recognize that ANS the organization will never take the place of industry trade associations like the Nuclear Energy Institute or the U.S. Nuclear Infrastructure Council. No, we will always be dedicated first to serving the men and women of the nuclear community, both here in the United States and around the world, as a source of news, technical knowledge, professional development opportunities, and scientific fellowship.

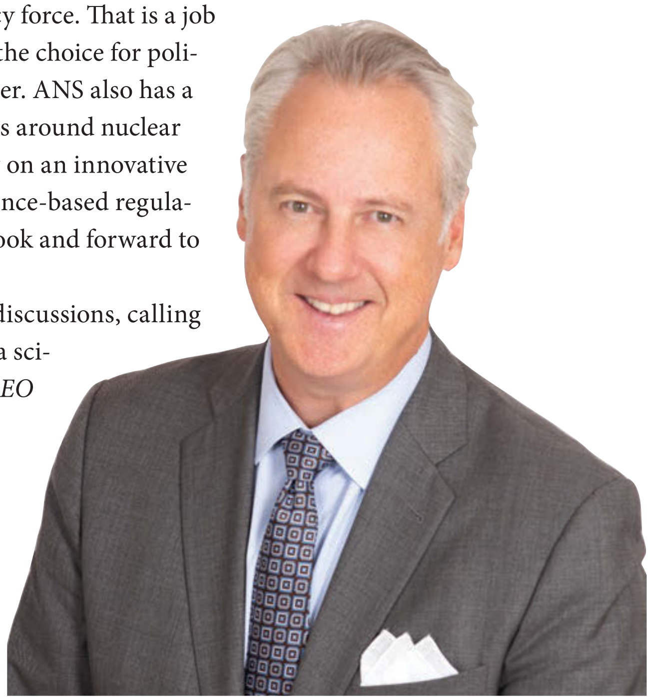
This should not in any way dissuade us, however—either individually or as a community—from engaging in the public discussion about nuclear technology, especially when debates become tainted by outright falsehoods or "fake news." As we have seen in stark relief over the past eight months of pandemic-dominated life, the scientific community has a societal obligation to stand up and set the record straight when misinformation crops up. Simply put, we have to be prepared to call balls and strikes.

As it happens, there will be a few fastballs coming our way in the next six months or so. Indian Point-3 is scheduled to go off-line next spring, and Exelon has now announced the closure of Dresden and Byron later in 2021. In each case, it is perfectly clear that the zero-carbon energy these plants generate will be replaced predominantly by natural gas, undoing decades of progress in decarbonizing those states' respective generation portfolios.

In Salt Lake City, Utah Associated Municipal Power Systems faces new headwinds as they push forward to bring the Carbon Free Power Project, the first commercial application of the NuScale Power Module, on line in 2029. Recently, several groups have organized local events to criticize the project. These groups, while professing to be concerned over the cost of the project, bear all the hallmarks of a classic antinuclear effort.

In each of these cases, ANS will never be the prime pronuclear advocacy force. That is a job for others. However, we have an affirmative role to play in helping frame the choice for policymakers, the media, and the public in an objective and fact-based manner. ANS also has a unique opportunity to help demystify some of the more complex concepts around nuclear technology and its uses. For instance, as you read this, ANS is embarking on an innovative social media campaign to explain the role of risk-informed and performance-based regulations using everyday situations and examples. I encourage you to take a look and forward to family and friends!

Ultimately, there is plenty of room for ANS to engage in these sorts of discussions, calling balls and strikes while maintaining our objectivity and independence as a scientific and professional organization.—*Craig Piercy, Executive Director/CEO (cpiercy@ans.org)*



UWC 2020: A call for transformational change

Bowing to current COVID-19 realities but buoyed by the success of June's virtual Annual Meeting, ANS event planners returned to the virtual realm for this year's Utility Working Conference. Originally scheduled for August 9–12 at Marco Island, Fla., the condensed event was held Wednesday, August 11, wherever registrants' computer devices happened to be located.

In addition to 26 educational sessions and workshops, UWC 2020 featured an opening plenary session titled "Achieving Transformational Change: A leadership discussion," moderated by Bob Coward, MPR Associates principal officer and ANS past president (2017–2018). Plenary panelists included representatives from Arizona Public Service (APS), Exelon, Xcel Energy, the Institute of Nuclear Operations (INPO), and the Nuclear Regulatory Commission.

Coward

In introductory remarks, Coward emphasized the need for transformational change in the nuclear sector via a slide showing the stark difference between the revenue that a utility might have expected to receive for a plant's power generation 10 years ago and what it can expect today. "If your plant . . . had the same capacity as Limerick, and you ran really well 100 percent of the time for that full 12 months, you were paid about $430 million less for your product than you were 10 years ago," Coward said. "When we talk about changes in the market, when we talk about the whole business model changing, that's the impact we're talking about. That's what we're up against. . . . Essentially every plant in the country, including the regulated utilities, are facing similar cost pressures. We as an industry, as one collaborative team, really have no choice. We have to adapt and evolve, and we have to get even better."

O'Connor

Xcel: Tim O'Connor, Xcel Energy's chief generation officer and executive vice president, talked of a "new grid reality," stating that he could see "as much as 50 to 70 percent penetration in intermittent resources in the next 10 years on almost any grid that we operate," which will require the nuclear industry to employ dispatching and idling strategies.

"I know we don't want to hear that, but that is a reality," O'Connor said. "What's the value of nuclear? We've been promoting that we're carbon free, we're promoting that we're good baseload units, and those are all solid. But is that what the grid's going to require? Not exactly. There are times when it will, there will be times when it won't. That is real, which means we're going to have to think differently quickly about how we operate these units and the service that they provide, which opens the door to other value streams that nuclear could provide."

One such value stream for nuclear, O'Connor noted, could be the production of hydrogen. "A clean energy source making another clean energy source that could be used in a larger environment, not just for electricity, but for other markets, such as steel fabrication, chemicals, fertilizers—just a whole host of opportunities," he said. "But I think that it's a winner. Now, it's not cost competitive yet, and that's the whole point of some of the research projects that are going on."

The new grid reality also demands better management of data, according to O'Connor. "We just plain manage data in a very arduous, human-centric approach," he said. "We have to accelerate artificial intelligence and other types of methods that can help us better understand the information we have and translate it in a way that allows us to be more agile, as well as accurate and focused around the running of these facilities. I personally believe that technology and data can absolutely step change our performance to meet regulatory, INPO, any number of requirements that are out there, and do it more efficiently, accurately, and with less likelihood of human performance error. And I think we can do it with less expense."

Lacal

Arizona Public Service: Maria Lacal, Arizona Public Service's executive vice president and Palo Verde's chief nuclear officer, agreed with O'Connor on the necessity of industry transformation, but she added that it needs to be tailored to a company's particular needs and culture and to its own societal, regulatory, and political environments.

"Each of us needs to use slightly different tools and apply different forces at different times as necessary," Lacal said. "In Arizona, we have a problem with increasing solar capacity within our state and the neighbor to the west of us, California. It's really created this issue of excess generation. And for us, negative pricing—it is available on the grid during certain times of the day and during certain seasons of the year, and we've got studies showing that by the year 2025 and beyond, the need for Palo Verde to flexibly operate becomes a reality. But I want to be really clear, if operating flexibly means operating less, we're really not interested."

What does interest APS is operating Palo Verde differently, Lacal said, pointing to its collaboration with other utilities and Idaho National Laboratory to develop and demonstrate an integrated light-water reactor hybrid energy system. The two-year project will initially demonstrate and deploy a 1–3-MWe low-temperature electrolysis unit to produce commercial quantities of hydrogen.

Continued

"For us, it's using excess energy from Palo Verde and creating hydrogen to do a blend at one of our fossil plants," Lacal said. "We really believe that the production of hydrogen from nuclear energy is going to enable and accelerate the decarbonization of the electric grid, as well as transportation and heavy industry."

Lacal also mentioned that a team from Palo Verde won the Nuclear Energy Institute's "Best of the Best" Top Innovative Practice Award in July for the use of artificial intelligence and machine learning. "We really need to continue to challenge our engineering and our support groups to transform how we use technology, thereby increasing our efficiency and decreasing our overall costs," she said.

On the regulatory front, Lacal endorsed a change to a more risk-informed type of NRC regulation. "I'm the chair of [NEI's] Risk Informed Steering Committee, and along with my colleagues, we are working very closely with the NRC on risk-informed initiatives," she said. "Eliminating the current administrative burden associated with low-safety-significance items not only makes good nuclear safety sense, but also good business sense. I think our ability to become more efficient and timely on regulatory decision-making by risk-informing our work results in increased margins to safety while reducing administrative burdens and costs."

Exelon: Scot Greenlee, Exelon's senior vice president of engineering and technical support, took a look back at topics discussed at UWC 2016 (he was the general chair of that conference) and provided updates on progress made since then as well as thoughts on what might be required going forward.


Greenlee

On the topic of simplifying the regulatory framework, Greenlee reported success. "It took us a long time—it was a very slow success—but the NRC just recently approved the 50.59 guidelines on digital upgrades," he said. "Essentially, what we have in place now is that we can do digital upgrades on anything except for plant protection systems. So that's a huge win. Now that we have control of most of our destiny for most of our systems, I think we can get to simplifying the amount of work that it takes to upgrade something from analog to digital."

Less progress has been made on equipment performance monitoring, however, according to Greenlee. "We're about 20 percent of where we need to be," he said. "We really need to get to the point where the computers do all of the performance monitoring and provide us with the outputs of when to go do maintenance."

Greenlee estimated the industry to be "20 or 30 percent down the road" on digital processes, but he added that the move to digital is accelerating. "We've put in place electronic work packages," he said. "That's an awesome platform, because you can do things like embed videos in your work packages so the maintenance folks can do just-in-time training to ensure that they're able to execute flawlessly."

There has been "terrific progress" on drones and robotics, Greenlee said—citing such examples as drone use for condenser inspections during outages—and "good progress" on risk-informed regulation and thinking.

Another 2016 discussion topic, accident tolerant fuel, was not something the industry had a huge amount of interest in at the time, according to Greenlee. Since then, however, the idea has "really moved forward quickly, and the challenge to our vendors is to have accident tolerant fuel in place by 2023," he said. "I think we're a bit behind on that schedule, though. For us, it's probably going to be more like 2024. There are risk-informed methodologies that we're starting to work on to accelerate the pace of accident tolerant fuel. But we've really just started to have the conversations with NRC on what that might look like."

Place

INPO: Jeff Place, executive vice president at INPO, provided a look at how the industry has responded to the pandemic—an agent of transformational change if anything is—and how the pandemic has altered his organization.

"Through the second quarter of 2020, the industry is performing at its highest levels ever," Place said, adding that industry performance in the second quarter actually improved from that of the pre-pandemic first quarter. "We saw the industry take some strong early actions as it rolled into the pandemic and made some of the initial changes to its workforce and workflows. There were a few human performance events that popped up—we were paying attention to that; we were working with the industry, and I would say that the industry took those on with resounding success. We have not seen the human performance events that we were seeing in the first couple of weeks in March. So the industry has become very resilient through this pandemic."

Place said that INPO is treating the pandemic as an opportunity to accelerate some of its innovations, including conducting some INPO activities virtually, such as remote accreditation team visits and material review visits. In addition, INPO now offers something called Virtual Online Leadership Training, or VOLT. "Just like the utilities, we believe we have to innovate as well, to do our jobs more effectively and efficiently going forward," Place said. "We are taking all of our operations through a formal innovation process."

Another of INPO's innovations is da Vinci, a reimagining of accreditation, according to Greenlee. "As all utility members recognize, going through an accreditation process . . . is a pretty large undertaking," he said. "So we worked with the industry. Some of the big key takeaways out of this is that we've eliminated the accreditation self-evaluation report, which was a roll-up, really, of all the self-evaluations that the utility had done at that station to get prepared for our accreditation process. We are just going to be looking at the actual individual self-evaluation reports. That's a huge savings for the industry, and we think that we get what we need to make good decisions. . . . We've already carried this out five times, and four of the stations have had their programs renewed remotely—they did not have to come in front of the accrediting board."

The NRC: The plenary's final speaker, Christopher Hanson, the newest NRC commissioner, returned to the topic of accident tolerant fuel early in his presentation. He stated that among the things he is most proud of from his time on Capitol Hill—where he served as a staff member on the Senate Appropriations Committee's Energy and Water Subcommittee under Sen. Dianne Feinstein (D., Calif.)—is his work on the Department of Energy's accident tolerant fuel program.

Hanson

"The program was a little slow to get going," Hanson recalled. "I can't speak to the utility side, but I can speak to the DOE side, and there were, I think, repeated attempts at DOE to deprioritize it. But with sustained focus and funding from Congress, I think to date three utilities have loaded, and I believe extracted, lead test assemblies. National laboratories have provided really valuable analytical support, and vendors are examining changes to their facilities to support eventual manufacture and distribution."

Continued

Also, while affirming the importance of the NRC's commitment to reasonable assurance of adequate protection, Hanson declared his approval of reform, transformation, and innovation. The agency is hard at work to ensure that it is a modern, risk-informed regulator, according to Hanson, ready to meet the challenges presented by a rapidly changing and innovating nuclear industry.

"It's also been reevaluating the way it does business to optimize its processes and procedures to better serve the American public, and these initiatives are taking place both across the agency as well as within individual program offices," Hanson said. "But to leverage the innovations developed within those individual offices, the agency is encouraging a culture that's open to sharing ideas and creating tools to easily do that. The executive director for operations has supported crowdsourcing initiatives, even creating a challenge campaign to identify alternative and more efficient ways of doing things."

Hanson also highlighted Embark Venture Studio, the Office of Nuclear Reactor Regulation's dedicated resource for promoting and implementing innovation projects to benefit the nuclear reactor safety program, as well as other NRC business lines.

The final ingredient in risk-informed regulation, and maybe the most important in my view, is culture and diversity.

As a further example of NRC innovation, Hanson pointed to the agency's mission analytics portal, which integrates data from different sources to give staff a clearer view of useful information. "For example," Hanson said, "it has dashboards that can show supervisors the distribution of open licensing actions and a comparison and estimated versus actual hours spent on those actions. In the future, we should be able to use the same tools to mine data from available sources such as inspection reports, so the data can provide insights we wouldn't otherwise see, leading to more transparent and informed decision-making."

In closing, Hanson provided his thoughts on risk-informed regulation and the NRC's move in that direction. "The final ingredient, I think, in risk-informed regulation, and maybe the most important in my view, is culture and diversity. Risk-informed regulation is really about characterizing uncertainty. There is necessarily a lot of professional and personal judgment implied in that. And data is critical, but we all know data can be interpreted a wide variety of ways. Having staff of diverse backgrounds and viewpoints helps ensure that uncertainties are fully understood and characterized, so NRC can provide reasonable assurance of adequate protection."

Additional sessions

For additional coverage of UWC 2020, see ANS Newswire (ans.org/news) for these articles on the conference's sessions covered by *NN* staff:

- More from UWC 2020
- More from UWC 2020: Round 2
- More from UWC 2020: Round 3

ATRC upgrade

Idaho's ATR Critical Facility undergoes a digital control system upgrade.

By Joseph Campbell

At first glance, the Advanced Test Reactor Critical (ATRC) Facility has very little in common with a full-size 800- or 1,000-MW nuclear power reactor. The similarities are there, however, as are the lessons to be learned from efforts to modernize the instrumentation and control systems that make them valuable assets, far beyond what their designers had envisioned.

One of four research and test reactors at Idaho National Laboratory, the ATRC is a low-power critical facility that directly supports the operations of INL's 250-MW Advanced Test Reactor (ATR). Located in the same building, the ATR and the ATRC share the canal used for storing fuel and experiment assemblies between operating cycles.

Low-power critical facilities such as the ATRC support the operations of their more powerful counterpart test reactors by offering precise calculation of neutron flux levels and other effects that will be seen at different test locations surrounding the reactor core. One of the challenges of operating a powerful test reactor with many different test positions is that for any given operating cycle, the wide variety of fuel and material experiments can affect the flux levels seen within the reactor. Designed as a low-power version of the ATR's core, the ATRC enables the accurate prediction of these levels and helps ATR reactor engineers select the fuel assemblies to be used for each cycle.

Continued

Reactor operators Craig Winder (foreground) and Clint Weigel prepare to start up the ATRC Facility reactor at Idaho National Laboratory after a nearly two-year project to digitally upgrade many of the reactor's key instrumentation and control systems.
Photos: DOE/INL

Designed and constructed in the early 1960s, many of the ATRC's original control systems were becoming difficult, if not impossible, to replace due to obsolescence and lack of vendor support. These factors were increasing downtime for repairs while replacement parts were found or fabricated.

After the completion of a nearly two-year project to design, install, and test new digital instrumentation and control systems that will greatly improve the precision and reliability of the facility to ensure that it can continue to support the ATR for several more decades, the ATRC was restarted earlier this year.

"Completing a project like this in such a short time is an amazing accomplishment," said Heath Buckland, manager of the ATR's Project Implementation Department. "Digital upgrading of complex analog systems is extremely complicated, and there are usually surprises when you tear into each of the system's many components. But the team completed the 18-month design, three-month execution, and operability testing phases of the project ahead of schedule and under budget."

Added ATRC Project Manager Travis Stoor, "We used a collaborative approach that included Curtiss-Wright, INL's human factors research team, and ATRC operators, craft workers, and systems engineers right from the beginning. That's really the key to the project's success."

Curtiss-Wright, an instrumentation and control systems engineering firm, handled the design and fabrication of the new system's digital components, bringing its extensive experience in both the commercial power and Navy nuclear propulsion industries.

"Extending the life span of aging reactors is critical for the continued success of the nuclear industry," said Matt Laux, manager of controls and quality assurance for Curtiss-Wright's Idaho Falls office. "Curtiss-Wright is honored to have worked with such a diligent and effective team to help modernize and enhance the reliability of the ATRC."

Continued

The ATRC Facility reactor at Idaho National Laboratory serves as a "dry run" facility to prepare new fuel and material irradiation experiments for their irradiation cycles in INL's Advanced Test Reactor.

Redesigned with intuitive interfaces and human performance standards in mind, the ATRC Facility reactor's new control systems are much easier for operators to manage.

Designing for a system that operates differently from all other reactors, even its more powerful "twin," the ATR, means working closely with the experts who operate it. During the 18-month design phase of the project, INL's human factors research team and ATRC operators collaborated on several prototypes. During workshops in INL's Human Systems Simulation Laboratory, rapid prototyping using an in-house-developed ATRC simulator molded the design to fit the specific needs of ATRC operations. The outcome is a unique research tool with improved reliability and efficiency. Operators also gained the benefit of an ergonomically correct workstation.

"The Curtiss-Wright team designed the console with our input and that of our human factors team, all with the end user in mind," said ATRC operator Craig Winder. "The original console designers definitely didn't do that. They were focused on functionality first and foremost, not realizing some of the error traps created by their very unintuitive design."

The upgrade project improved visual displays, using sturdier, modern buttons and switches and updated readout screens. All of these were arranged to support simplified, intuitive operations, such as the outer shim controls for the four lobes of the reactor. Their arrangement on the panel matches the physical layout of the reactor itself, unlike the original design, which was not so intuitive for the operators.

Combined, these improvements led to a greater number of operating days and more research milestones accomplished with fewer delays and at lower cost.

The new control panel design replaces complete portions of the original frame and control wiring. The new frame incorporates two 42-inch monitors, a redesigned stainless-steel operator desk, and new digital recorders for the Log-N/Period channels. Control wiring was installed using redundant programmable logic controllers, with a new network control system to communicate with new encoders for position indication.

"I was nervous and skeptical at first, when they decided to attack this project in phases, rather than doing the entire system at once, but it turned out to be the right approach," said Jim Lowden, ATRC reactor supervisor. "I've been completely awed by how this team was able to meet each challenge that came up along the way."

Buckland said, "ATRC is a very important step for most experiments slated to go into ATR itself, and demand is expected to continue growing. This was a risk for all of ATR's experiment programs that we had to address, and the team really rose to meet the challenge."

Joseph Campbell can be reached at Joseph.Campbell@inl.gov.


We are your Expert, Craftsman & Partner
Our goal is to make our customer's job easier. We provide turnkey material handling solutions for all generations of nuclear power plants. Our quality is built on depth of capabilities, with an integrated approach, in-house resources and experience.
MARKET LEADER IN CRITICAL LIFT CRANES
GRIT MATTERS™
ACECO American CRANE & EQUIPMENT CORPORATION
CORPORATE HEADQUARTERS
531 Old Swede Road ▪ Douglassville, PA 19518
877.877.6778 ▪ fax: 610.385.3191
AmericanCrane.com

The **Nuclear**News Interview

Ratliff and Harris

Innovation for safety and reliability


Jay Ratliff


Floyd Harris

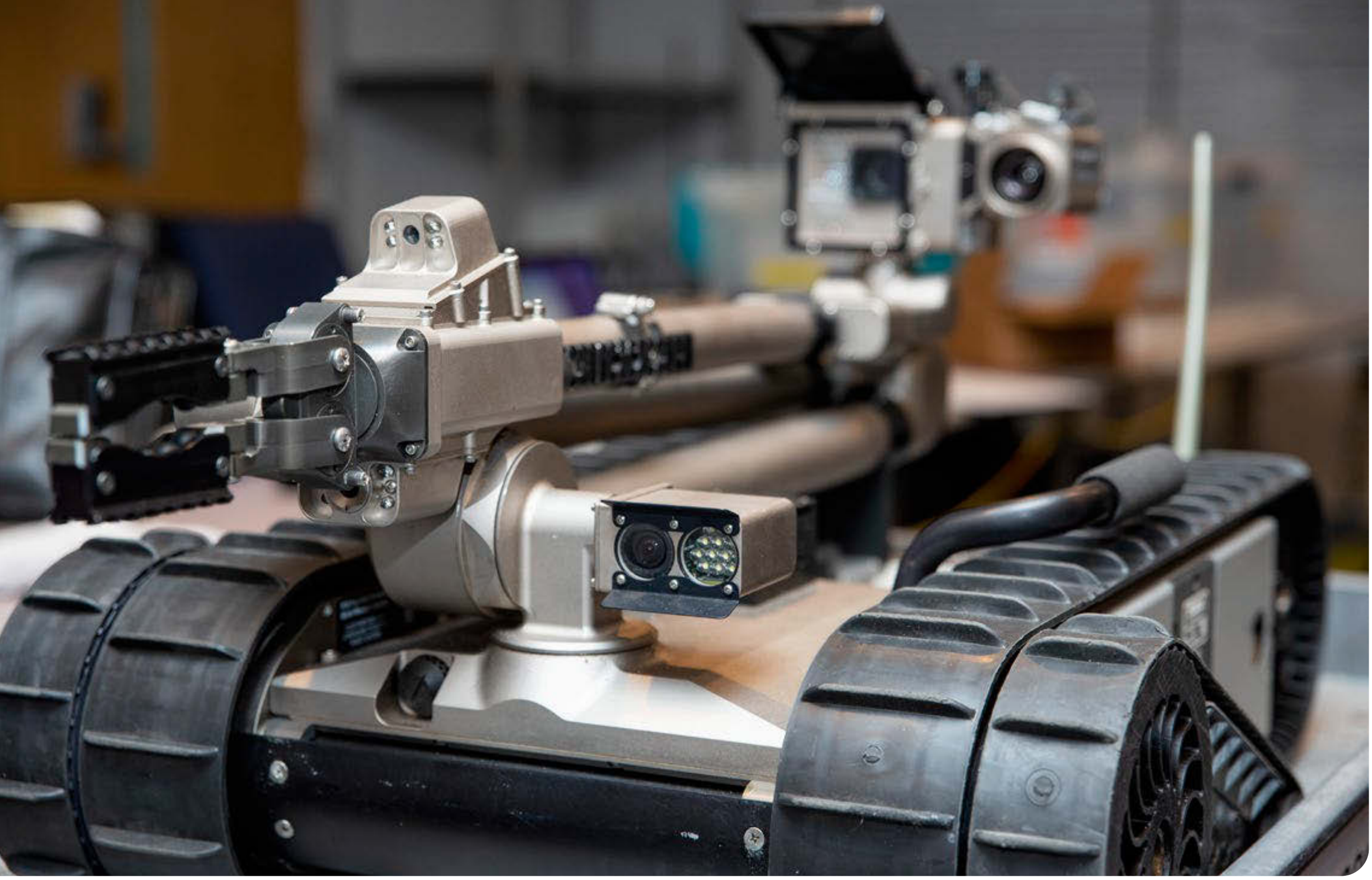
When Floyd Harris began working at Duke Energy's Brunswick nuclear plant about 24 years ago as a radiation protection technician, robotics and remote monitoring were considered tools for radiation protection and nothing more. Now, teams from across the site, including engineering, maintenance, and operations, rely on the system of robots and cameras Harris is responsible for. "If you want to put those technologies under one umbrella," says Harris, who now holds the title of nuclear station scientist, "it would be monitoring plant conditions."

That monitoring is critical to effective plant maintenance. As Plant Manager Jay Ratliff explains, the goal is to "find a problem before it finds us" and ensure safety and reliability. *Nuclear News* Staff Writer Susan Gallier talked with Ratliff and Harris about how robotics and remote systems are deployed to meet those goals.

At Brunswick, which hosts GE-designed boiling water reactors in Southport, N.C., ingenuity and hard work have produced a novel remote dosimetry turnstile to control access to high-radiation areas, an extensive network to handle data from monitoring cameras, rapid fleetwide access to camera feeds to support collaboration, and new applications for robots and drones.

Continued


Brunswick Nuclear Power Plant
Photos: Duke Energy



One of the three PackBots used at Brunswick for inspections and minor repairs.

What drives Duke Energy's investment in robotics and remote sensing at the Brunswick plant?

Ratliff: It really comes down to radiological and industrial safety and how we can maintain safe and reliable operation of the plant and the safety of our employees and the public as well. The investments we've been able to make in technology allow us to put safety first and let us perform remote monitoring and identify conditions in order to address them. If we can identify a component before it fails, we can prevent a failure from cascading or creating impacts to other trains in reliability, and we can address it on our timeline versus an emergent response. The system is used for information gathering, and any data must be confirmed before it's used for decision-making.

Can you describe your fleet of robots?

Harris: There are a lot of different devices that we use. From Endeavor Robotics [acquired in 2019 by FLIR Systems] we have the FirstLook, which is a smaller robot. We have two of those. Next is the PackBot, which is a medium-sized robot used mostly for identifying issues or doing minor repairs—we have three PackBots. Our largest robot, also from Endeavor, is a Warrior. We also have drones that we utilize to get to locations that are not readily accessible without a ladder or scaffolding. We have two Elios drones from Flyability.

Do you use drones both inside and outside the plant?

Harris: Yes. We've used them in the turbine building, for example. A challenge is the environment into which we put the drone. We want to make sure the drone survives since we have made an investment in the technology. We pick and choose the conditions that we want to put it in that will maximize the reliability of the drone.

About a year and a half ago we sent one into the waterbox to inspect for leaks. We also ran it up 80 feet in the drywell at initial entry to identify an issue instead of sending in an individual, because the temperature was exceeding 135°F.

Above: Brunswick uses Elios drones to carry out inspections that would otherwise require ladders or scaffolding.

Right: Brunswick's William Kerr, plant lead for drone technology, operates an Elios drone.

We have an Elios model that has thermography ability that will allow us to identify temperature gradients that could tell us if a system is in service, if we have pressure or temperature flow on a certain pipe, for example.

Ratliff: The PackBot and the Warrior robots have similar capabilities. We have the capability of thermal imaging and remote area radiation monitoring because there are different payloads that can be added to the devices.

Continued

The feed from installed cameras can be accessed from any location within the Duke Energy fleet.

How did you use robotics during Brunswick-1's March refueling outage and June maintenance outage?

Ratliff: The greatest benefit was visual inspections. It allows us to perform an inspection on equipment in the drywell or in the main condenser that otherwise would require us to build scaffolding and put folks in climbing gear and fall-protection harnesses and so forth. We can use the drones and the robots to perform those inspections and record the data. Once we identify conditions that we need to address, then we can build scaffolding at that location and do it safely. We minimize the need to put staff in an elevated position or an awkward location.

I've heard that Brunswick has one of the industry's largest remote monitoring systems. How do you quantify the size or scope of that system?

Harris: Brunswick currently has about 200 cameras online to support operations and to support plant needs—everything from engineering to instrumentation and controls. I'm actually adding three more today. During an outage, we'll probably have about 270 to 275 cameras available. Typically we install another 35 to 40 cameras during an outage.

Ratliff: In the past year, we've actually added to the fiber-optic backbone of the system and installed additional cabinets with dedicated optic video networking switches. We can put about 750 devices onto the system and it doesn't impact the business network. We put a fairly significant investment into the facility to be able to remove that roadblock so that all of these camera systems can talk without limiting bandwidth. We can easily install a camera in just about every place on this plant site.

We also have an audio system that gives us the capability to communicate with a worker who is down in the reactor cavity. We can communicate with that person through any business network PC within the fleet. That gives us the ability to be in the corporate office in Charlotte and pull up a live image of individuals working in the cavity or elsewhere in the plant. It also gives us video, audio, and teledosimetry capabilities to provide remote monitoring job coverage from another site. We've had an individual provide remote monitoring job coverage for the drywell and for the refueling floor during the outage at Brunswick while stationed at the Harris plant, freeing up people at Brunswick to do other tasks.

installed is called motor current signature analysis. The current transformers measure the current coming through the cables that are supplying power to the motor. It can compare all three phases and look for any kind of imbalance or shift. If something mechanical were to change in the pump, such as a bearing starts to seize up or the cooling water flow ceases and the pump is running at a hotter temperature, then we can identify that before it impacts the component itself.

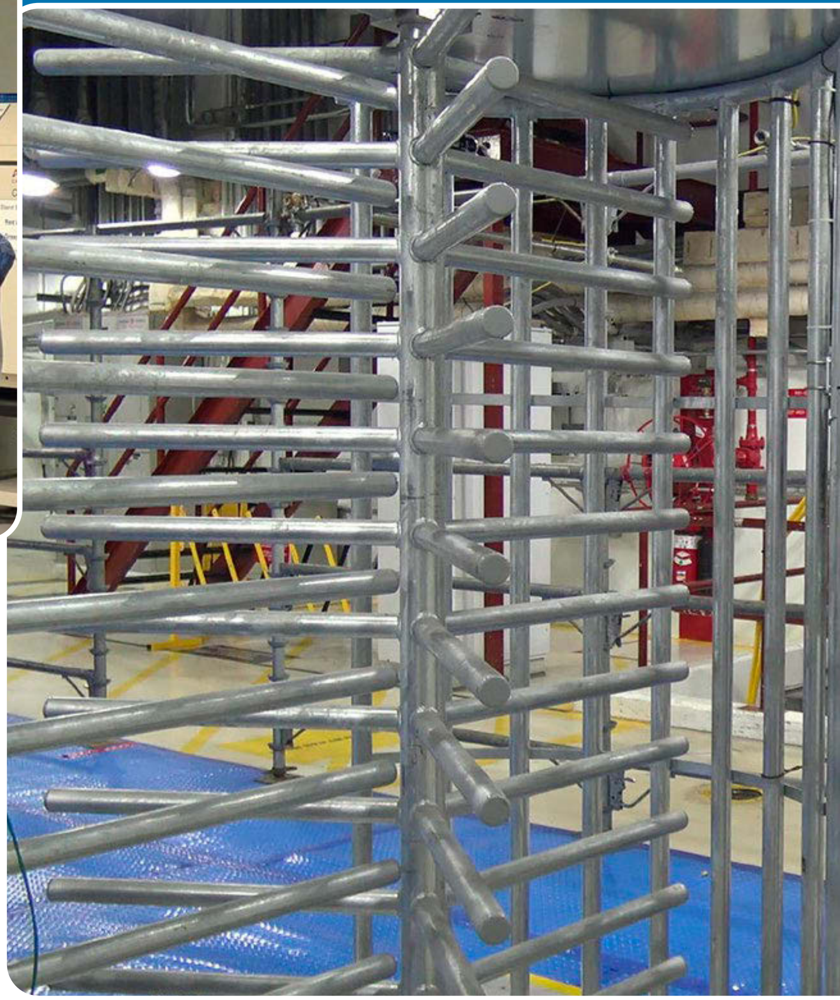
Continued

How do the cameras installed in the plant support your maintenance program?

Ratliff: We strategically place cameras around the facility in areas where we want continuous monitoring. We use cameras to monitor parameters such as pressure, temperatures, and flow throughout the plant. We can take video footage of gauges and utilize pattern recognition technology and convert that still image into data that can be stored and tracked on a graph as well. We can also see how quickly parameters are changing. If we see a step change or something that starts to decrease, whether it's pressure, temperature, flow vibrations, or something else, we can set alarm set points for flow thresholds to know the pump is saying, "Hey, come look at me. I have something going on here."

Another use of the pattern recognition technology I just described is a wireless gauge reader that can be put on an analog or digital gauge. We can use this wireless reader to take an image of the analog gauge, just like the gas gauge in your car, and convert that to a digital signal, which can be sent over a wireless network. We started implementing that in the beginning of 2019. We have a number of those in use around the plant. They give us more data to analyze so we can identify conditions.

The latest technology we've



Above: Nuclear Station Instructor J.T. Thomas walks workers through the process for accessing the drywell during the March 2020 refueling outage at Brunswick-1. The process begins here, where personnel get a briefing and a 360-degree look at where they are going from a camera installed in the drywell before they enter the locked high-radiation area.

Right: After a briefing, workers approach the remote monitoring turnstile installed to control access to the drywell and make audio contact with a remote radiation protection technician.

Do you buy equipment off-the-shelf, collaborate with vendors, or some of both?

Harris: It takes a little of both to come up with a tool that suits our needs. We use several different vendors for remote monitoring. When I say remote monitoring, I'm referring to camera audio, video, data, and robots. The vendors are pretty good about helping us. We've also developed some ourselves.

What have you built yourselves?

Harris: Most recently we built a remote monitoring turnstile using an off-the-shelf turnstile that you would typically use for security access. We integrated all the necessary radiation protection controls to control access at a locked high-radiation area. The turnstile has a teledosimetry reader, and it gives the radiation protection technician the ability to view a worker's teledosimetry. The RP tech has a PLC [programmable logic controller] that controls the turnstile, they have the workers on camera, and they also have two-way audio communication with the worker. The RP tech unlocks the turnstile through the screen on the PLC. It's got all the bells and whistles—it only allows one worker at a time, and it allows egress of the area for fire and safety.

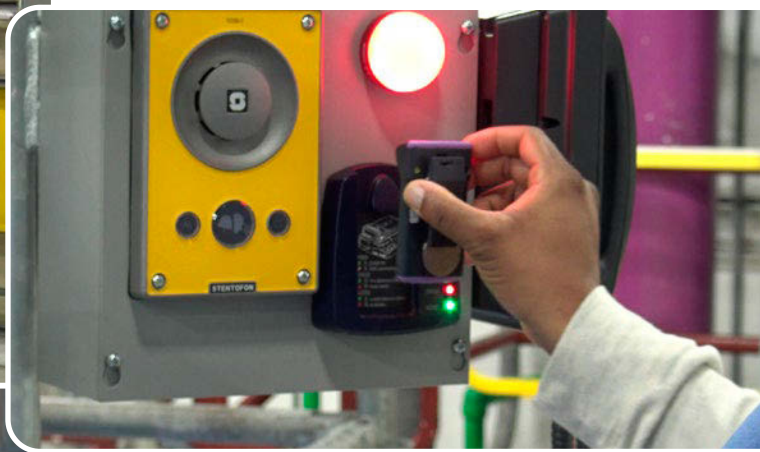
Before this turnstile system was installed at the entrance to the drywell, which is a locked, high-rad area, we would have an RP tech sitting there at that entryway the entire time, dedicated to that single task. Installing the remote monitoring turnstile allows the RP tech to sit in a remote location where they can monitor two or more high-rad areas or do other tasks as well. We can meet the same functions and better utilize personnel.

During a 24-day outage in March, the turnstile device alone saved us approximately 800 person-mRem of exposure versus having an RP tech sitting at the entryway.

Continued

Below: A close-up of the dosimeter reader installed at the drywell turnstile.

Bottom: With the light now green, a worker can pass through the unlocked turnstile.



Do you share equipment and resources within the Duke Energy nuclear fleet?

Harris: Yes, we share within the fleet. For example, if there is a part or piece of equipment that our McGuire plant may need, they will call and we will send it to them—and hopefully they don't keep it!

Ratliff: Especially now with use of Microsoft Teams, we can get a jump on conditions across the fleet using the technology. Within a matter of minutes, we can have every station represented in an online meeting, with all of their subject matter experts. We can take control of the screen on Teams, put the video up, and in a matter of minutes we can demonstrate the issue and its challenges. We have all of this brain power at our disposal almost instantaneously.

We also use the system to communicate with GE and with operators and technicians at the other BWRs that were designed and built by GE. Having the camera and video footage and being able to share that instantly helps a lot.

We can take control of the screen on Teams, put the video up, and in a matter of minutes we can demonstrate the issue and its challenges.

You've built a reputation for your robotics and remote sensing program. How do you share that knowledge?

Harris: A lot of it is informal. When I go to a user-group meeting I'll create a presentation for what we do at Brunswick and share that with the group. The meetings are also a good source of new contacts. They'll call and ask questions, and we'll share information.

The reality is that some sites may not have a subject matter expert for remote monitoring with the expertise it takes to install that fiber backbone for a camera system and for robotics. A site is lucky to have one. And if they've got two, that is extraordinary.

When and how did you get into robotics at Brunswick?

Harris: I actually did audio and video and data back at San Onofre in 1986 and that's what got me started. I've been at Brunswick for about 24 years now. You could say I seized the moment and continued with it here at Brunswick. Brunswick has allowed me to pursue a passion.

I worked with Daren Cato, who was my peer in radiation protection at Duke Energy's Robinson plant, for quite a few years. Back when we were utilizing analog cameras there was no real IP network. We started looking at robots and different tools that we could use to help with exposure to find the ones that would best suit our needs. Remote monitoring was just a radiation protection tool back in the 1980s. It's grown today into a tool that the whole site uses.

How would you describe the impact of Brunswick's robotics and remote monitoring program on schedule, cost, or dose?

Ratliff: I would say it's mostly about safety and reliability and less about schedule, cost, and dose. Safely and reliably operating our plant is the dominant driver for the technology of remote monitoring and robotics. Now we do see efficiencies, which translate into schedule and cost. And we also see less dose impact because the dose is to the robot or the drone or the submersible technology. Catching early signs of potential equipment issues could have a tremendous impact on schedule, costs, and dose. But as I said before, it's really about the safety of our employees and the public.

How has COVID-19 affected your programs?

Harris: We have a portion of our workforce working remotely. In the past, it was much easier to grab your hard hat, safety glasses, safety shoes, and a pair of gloves to go out into the plant to see what you wanted to look at. But with the COVID-19 posture, if you're not on site you don't have the ability to do that. Pulling up the camera system, identifying the camera for the location of something you want to look at, and then evaluating it—we've become extremely proficient at that. There will be a transition at some point out of the COVID-19 protocol, and we will find that personnel have become much more familiar with this system. It will have become second nature.

What is on your wish list? What else could be handled with robotics and remote systems?

Harris: As far as my wish list goes, that would be to reach the full potential of the devices we have. For example, tying the live video stream from our robots to the software we use for our stationary cameras. Tying all the parts and pieces together would be a great asset for the site and for all the disciplines here at Brunswick and in the entire fleet.

Ratliff: I would offer that the more we can automate, the better off we are from a safety and reliability perspective. Our whole plant reliability initiative is that we find a problem before it finds us. That's really our goal.

Solving Sellafield's 4 Ds problem

By the U.K. National Nuclear Laboratory
and Sellafield Ltd

Though robotics solutions have been used across many industries, for many purposes, Sellafield Ltd has begun to bring robotics to the U.K. nuclear industry to conduct tasks in extreme environments. The Sellafield site, in Cumbria, United Kingdom, contains historic waste storage silos and storage ponds, some of which started operations in the 1950s and contain some of the most hazardous intermediate-level waste in the United Kingdom. There is a pressing need to decommission these aging facilities as soon as possible, as some of them pose significant radiation risk.

Continued

The U.K. National Nuclear Laboratory's Colin Fairbairn (left) and Ben Smith (in pre-COVID days) work on the Box Encapsulation Plant (BEP) robots project at the NNL's facility in Workington, Cumbria, U.K. Photos: UKNNL

In some of these facilities, Sellafield operators must work in limited-access and/or dangerous environments, with conditions often described using the 4 Ds: dirty, dark, dangerous, and dull. Through the use of remote robotics, however, Sellafield can remove operators from these dangerous environments and also assist with boring, repetitive tasks, thus reducing the risk of human error.

Two of the commercial robots that have been customized for the BEP work.

Above: **Fairbairn and Smith work at the remote teleoperation control center for the customized robots, which supports the removal of human operators from hazardous environments.**

The United Kingdom's National Nuclear Laboratory works alongside Sellafield to explore the use of robotics and artificial intelligence solutions on Sellafield sites through the Sellafield Central Robotics and Artificial Intelligence Team (SL Central RAI Team). This team conducts continuous research into evolving RAI solutions in both the supply chain and academia to understand where the modification of inexpensive commercial-off-the-shelf (COTS) technology is suitable, or whether a more tailored, bespoke solution is required. Examples range from small, adapted, COTS remotely operated vehicles used typically for exploration and measurement of radiation, to the pictured robotic arms (photos taken before the COVID health emergency) typically used for manipulation of larger objects and controlled from a remote control desk.

Continued

A worker calibrates a laser-cutting robotic arm at the NNL's facility in Preston, Lancashire, U.K. Photo: UKNNL

For each of these solutions, the robot is operated remotely, removing the risk of human exposure. Beyond this, the sourcing and implementation of these solutions are conducted with the end users in mind, ensuring that the robotics are deemed fit-for-purpose by the very individuals intended to use them.

It is through exploration of these potential solutions, in collaboration with the end users, that the SL Central RAI Team can utilize robotics that remove operators from dirty, dark, dangerous, and dull environments, while improving efficiencies to manage the historic legacy waste on a shorter timescale.

For further information, contact the SL Central RAI Team at robotics@sellafieldsites.com.

Diakont technicians prepare an NDE inspection robot for deployment into a diesel tank. Photos: Diakont

Robotics for plant maintenance:

NOW AND IN THE FUTURE

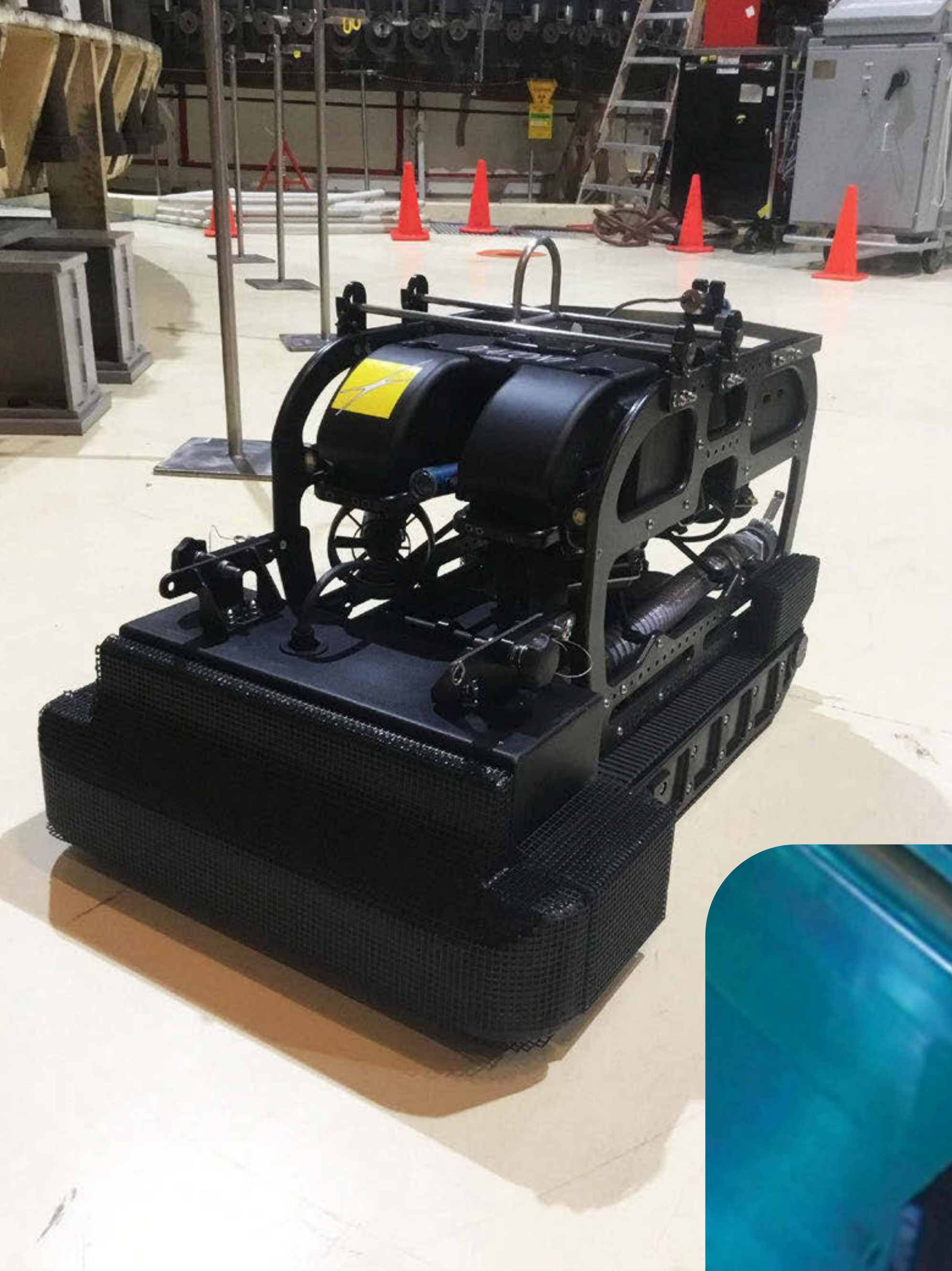
By Tobias Haswell

Robotics and remote systems have been used for supporting nuclear facilities since the dawn of the atomic age. Early commercial nuclear plants implemented varying levels of automation and remote operation, such as maintenance activities performed on the reactor pressure vessel and steam generators. Over the past several decades, there has been a steady progression toward incorporating more advanced remote operations into nuclear plants to improve their efficiency and safety. One of the primary forces driving the adoption of robotic tooling in U.S. nuclear power plants is money.

The economic model for the U.S. operating fleet has changed considerably over the past 10 to 12 years. Regulations in the nuclear industry have rarely decreased and, more often than not, have increased. This has led to nuclear plants in certain energy markets being hindered financially and thus needing to find ways to optimize their operations to do more with the resources they have. At the same time, the reliability and flexibility of robotics and automated systems have been increasing while their costs have been decreasing, making robotic systems much safer and more available to use. This has helped drive utilities to explore new ways of using robotics to overcome the obstacles they are facing. One of the obstacles that power plants have been tackling has been shortening the duration of their refueling outages to decrease their costs and increase their revenue.

In the past, outages may have lasted a few months, whereas now some take only a couple of weeks. In part, the decrease in the duration of the outages has been a result of improvements made to the operation of the plants, which has included the implementation of robotic and automated systems. In some cases, the use of robotics has allowed operations that previously needed to be done in a linear order (one after another) to now be done in parallel, which has the potential to cut hours or days off of outage schedules.

Continued



A decontamination ROV on a dry surface and in action in a refueling cavity.

One example of this is the use of a submersible ROV (remotely operated vehicle) that my company, Diakont, uses to perform remotely operated robotic decontaminations within the equipment pits and reactor cavity pools during fuel moves.

During the outage, the reactor is disassembled so that the plant can access and move the fuel rods located within the reactor. To protect plant personnel from radiation during this time, the equipment pit and reactor cavity pools are flooded with water, which helps to shield the personnel from the radiation. While the water is protecting the personnel from radiation, it is also spreading contamination from the fuel rods onto the surfaces within the pool. Toward the end of the outage, these pools will need to be drained so that personnel can go into them and perform work on the reactor pressure vessel head.

Before the work can be performed, the contamination must be removed from the surfaces inside the drained pools. Traditionally, this has been done by hand by human technicians after the water has been fully drained.

The benefit of using an ROV to decontaminate these pools while there is still water in them is two-fold. First, because the surfaces are being decontaminated in parallel with the fuel moves and other refueling activities, the plant can save a significant number of hours in its outage. Also, any contamination that is remaining within the pools after the drain down is drastically reduced, with radiation levels that could be 50 percent of what they would have been otherwise. By using a robotic solution instead of human technicians in this case, plants can reduce costs while also improving safety.

Improving the safety of existing plant operations has been another motivating factor for the introduction of robotic solutions. To minimize or eliminate the use of human divers, underwater robots are beginning to be used when work needs to be done in areas such as a suppression pool or an intake structure, which helps to reduce the risk of bodily harm to plant personnel. In addition, the use of industrial unmanned aerial vehicles (drones) can perform aerial inspections in minutes while also avoiding the risks posed to humans by the use of scaffolding or rope access. The use of robotics in these situations has removed humans from conditions that previously put them in danger.

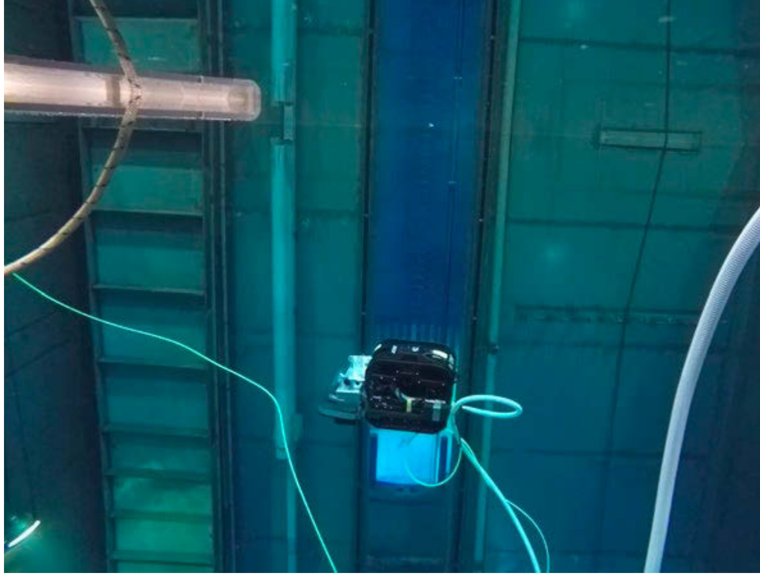
New plant maintenance activities, not historically performed, are being conducted for the first time robotically. Examples of this include balance-of-plant inspections required in accordance with an aging management program or regulator commitments from license renewal. Diakont provides robotic solutions for many of these new activities such as inspections of storage tanks for refueling water, condensate, or diesel fuel. These inspections can be done without removing the tanks from operation and, in most cases, avoiding a Limited Condition for Operation. Diakont also performs robotic ultrasonic testing inspection of buried piping, needed to ensure the detection of any corrosion that could lead to leaks that would contaminate groundwater. Other new applications in the industry include the use of remotely operated systems to perform the inspection of dry fuel storage canisters from inside their overpack casks. The introduction of new neural network technology is being used to perform automated visual analyses of fuel assemblies in real-time, which can identify the presence of debris or foreign material that could lead to cladding leakage.

The pandemic this year has given a major push to the nuclear industry to try to limit the number of personnel allowed on-site. Many U.S. plants were impacted by the pandemic just as Spring 2020 refueling outages were starting. These plants were forced to begin looking for ways to adapt as quickly as possible to limit the number of personnel on-site, which was accomplished often by eliminating activities that were not deemed absolutely critical at that time.

Continued


Bob's Crane Service

Right: An ROV in use at a test facility inside a mockup of a reactor cavity pool. The ROV can be employed into a variety of pools, most often in the reactor cavity pool and the equipment pit pool (also known as the dryer/separator pool). The ROV is capable of attaching and driving (using tracks) on both the walls and floors inside the pools. While it drives around, it also uses a brush to scrub the walls and floors, removing contamination, which is then sucked up a hose to a filtration pump. By doing this, the walls and floors are decontaminated in parallel with other outage activities, saving both time and dose to the personnel when the pools are drained during reassembly of the reactor pressure vessel.



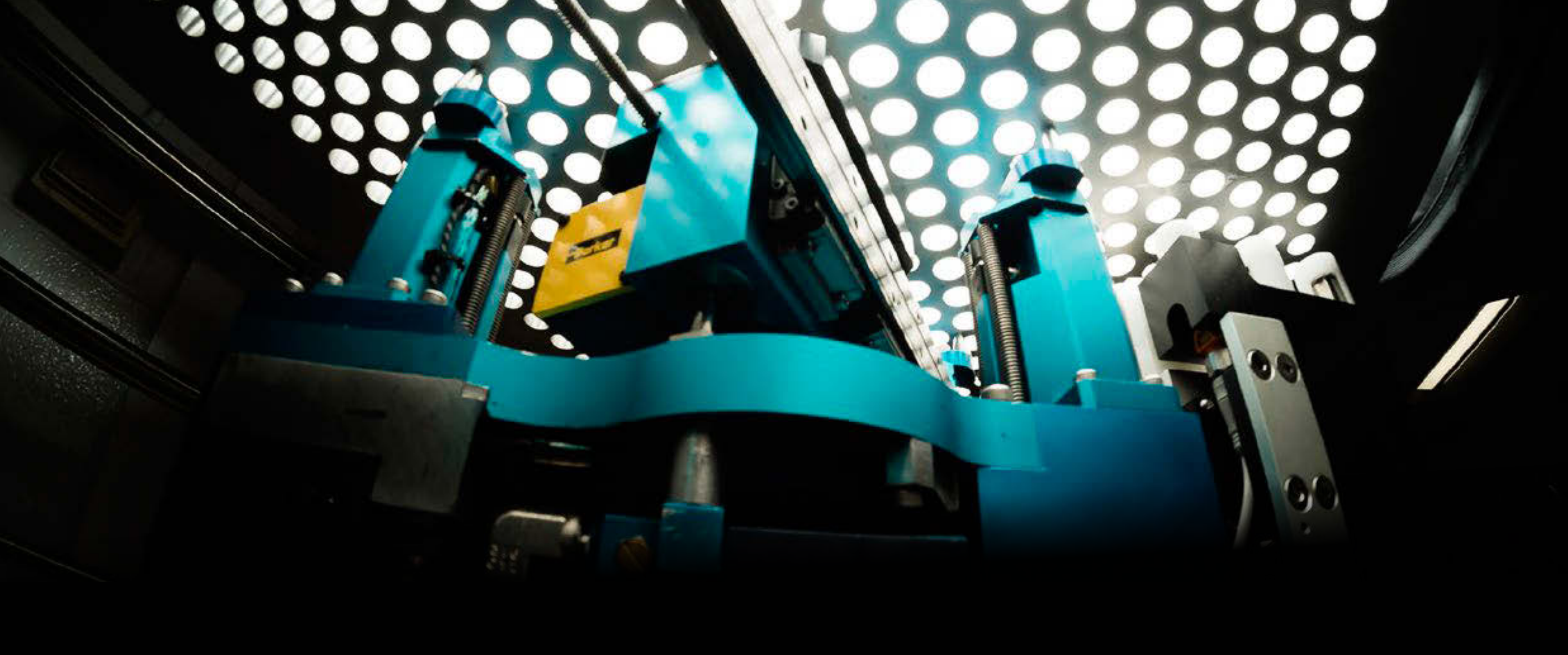
However, these activities will eventually need to be performed. Remotely operated robotic solutions will be a great solution for eliminating the need for personnel to be involved in activities that typically would not allow for social distancing. It won't happen overnight, but nuclear facilities have already started looking into how to use robotics as an alternative. Looking forward, there will be a renewed, permanent push to do more tasks with robotics and remote tooling, even post-COVID.

The future for robotics in the nuclear industry is looking bright. With secondary license renewals, the current operating fleet of plants in the United States is now being licensed to operate into the 2050s—more than 30 years from now. If you consider that 30 years ago technology was still mostly analog, we can imagine how much the industry will grow in these next 30 years. In our current age, most maintenance activities still require personnel to perform them by hand. By leveraging future robotic technology that can navigate the existing stairs, airlocks, and catwalks of a plant, more and more maintenance activities will be able to be done by robotics while the plant remains on line. There may be a day when an untethered robot can go into containment for a 100-percent power entry. That robot will be able to withstand the radiation and temperature while using thermal imaging and LIDAR (light detection and ranging) to navigate. Checking potentially erroneous alarms, the temperature on a bearing, or replacing a faulty sensor are just a few of the advantages that this robot would provide. All the while, a licensed operator would be safely situated outside the radiologically controlled area. It is the application of technology such as this that will continue to increase the reliability and capacity factor of the existing fleet, allowing it to continue to meet our carbon-free baseload generation needs.

Whatever challenges the future may hold for the nuclear industry, one thing is certain: robotics will be leading the way in solving those challenges. New technology is constantly being introduced and obstacles are being overcome. Whether it's robots that fly, climb stairs, or swim underwater, the industry is abounding with new robotic solutions that will reshape how we think and how we perform services in the nuclear industry.

Tobias Haswell (thaswell@diakont.us.com) is the Robotic Decontamination Program Manager for Diakont.

Left: A UT robot is prepared by Diakont technicians for inspection deployment into service water piping.



ROBOTICS AT PALO VERDE

By Rick Michal

The plant's Program Engineering Department head has overseen significant new technology implementations for maintenance.

The Palo Verde Nuclear Generating Station, a three-unit pressurized water reactor plant operated by Arizona Public Service Company, has started using an inspection technology relatively new to the nuclear industry. The technology, called smart pigs (an acronym for "piping inline gauges"), has previously been employed by oil and gas companies for inspecting and cleaning underground pipes. After testing and analyzing smart pig products from several companies, Palo Verde's underground piping consultant, Dan Wittas, selected a smart pig suitable for navigating the tight-radius bends in the plant's spray pond piping. The spray pond system consists of piping, a pump, and a reservoir where hot water (from the Palo Verde plant) is cooled before reuse by pumping it through spray nozzles into the cooler air. Smart pigs work by using the water's flow through the piping to move an inspection tool within the pipe itself. The technology replaces the previous method of pipe inspection, in which various relatively small sections of piping were unearthed and directly inspected, and were considered to be representative examples of the overall piping condition. In contrast, the smart pigs obtain corrosion levels for the length of piping traveled through and allow a corrosion baseline to be established.

The smart pig technology is just one of the robotic systems recently introduced at Palo Verde, according to Boris Bolf, leader of the plant's Program Engineering Department. Bolf has worked at the plant near Tonopah, Ariz., since February 1992.

Continued

Top left: The Zephyr system uses probes for steam generator inspections. Photos: APS

Boris Bolf

A set of smart pigs.

As the head of the department, Bolf is responsible for ASME-mandated inspections and maintenance on steam generators, heat exchangers, air-operated valves, motor-operated valves, and underground piping, as well as prevention of flow-accelerated corrosion, Inconel 600 degradation, and boric acid corrosion.

Among the new technology at Palo Verde is an analysis system called RevospECT, from Zetec, used to assist with eddy current testing of the plant's low-pressure feedwater and balance-of-plant (BOP) heat exchangers. The new system, implemented by Rachael Harley and Doug Hansen of Bolf's Programs Engineering team, can take in large amounts of data and screen it in a reliable and consistent manner. "This helps improve the reliability of the heat exchangers while improving the plugging decisions based on known wear rates and not conservative ones that would ultimately reduce the life of these valuable plant assets," Bolf said.

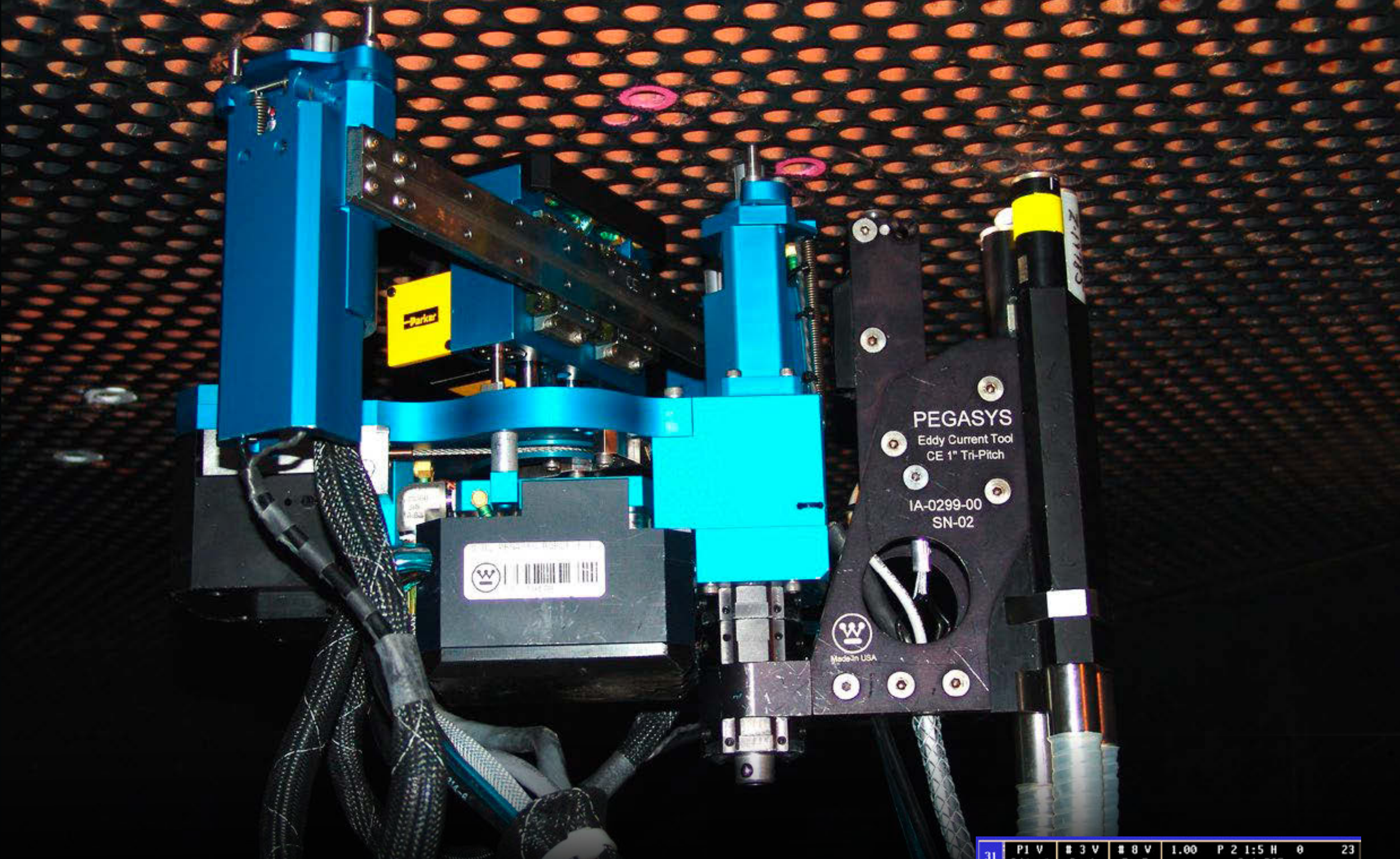
Also new at the plant is what Bolf calls a hyperspectral imaging camera, by Specim. Bolf explained that ultrasonic inspections inside containment have sometimes revealed that a couplant jelly has not been adequately cleaned off piping. (Couplants typically are moderately viscous, nontoxic liquids, gels, or pastes.) In many cases, leftover jelly has been flagged as evidence of potential boric acid leakage during subsequent walkdowns—both boric acid and leftover couplant leave a white powder residue on plant surfaces. Given the serious regulatory requirements surrounding boric acid leakage control, the presence of an unidentified white substance historically has required plant resources to collect samples and have them tested at a qualified radioactive testing laboratory. Now, however, the hyperspectral imaging camera can help.

The boric acid checks are performed by Palo Verde metallurgists Tom Malota and Troy Wilfong, who have also tested the capability of the new imaging camera and verified that it is properly calibrated to determine if any substance found on piping is boric acid, couplant, paint, or some other material. "This device will save man-hours, analysis expenses, and radiation dose that would be expended to obtain sampling," Bolf said.

Regarding other plant work, inspections of check valves historically required full disassembly, but many inspections are now being performed using phased array ultrasonic testing technologies. Palo Verde's Domingo Cruz has been on the forefront leading the nuclear industry and helping the plant verify that its check valves are ready to perform their intended design function, which is stopping reverse flow. The phased array testing technology has allowed verification on many more valves than would be possible in the past, which has increased their reliability while saving the manpower of having to perform a complete disassembly.

Another time saver is the Zephyr probe, developed by Zetec. The new probes are used for eddy current inspections of steam generators. The Zephyr probes travel at double the speed of normal eddy current probes, according to Bolf. "This shortens our eddy current window by half, reducing the window to inspect the steam generator while maintaining a high standard of inspection fidelity," he said.

A closeup of the Zephyr inspection system.



Bolf noted that the plant also has started doing more remote analysis work for eddy current inspections because of the ongoing pandemic. "We plan to continue that practice to reduce the chances of bringing COVID to the site," he said. "Due to how well these processes worked remotely, this will most likely become the standard."

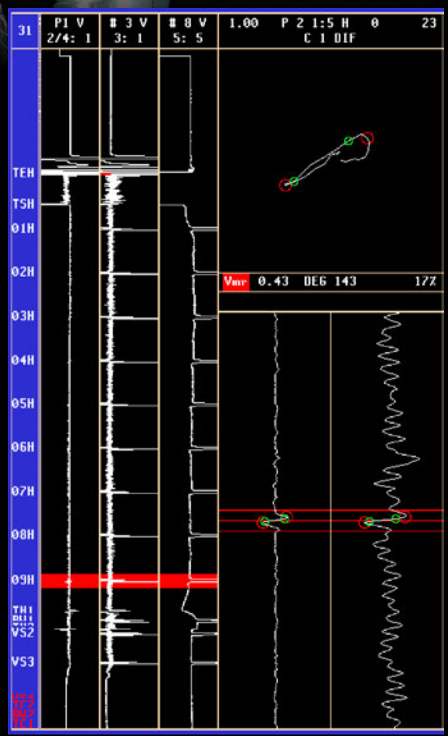
Other maintenance activities involving robotics include magnetic drive inspections on all reactor head control rod drive mechanism penetrations and bottom-mounted nozzle penetrations for boric acid indications that would point out a pressure boundary leak.

Robotic inspection tools have reduced radiological exposure for workers because the bottom of a reactor head and the associated instrumentation guide tubes are areas of high dose rates.

Palo Verde is also working on new technologies to improve the service life of its demineralizer vessels. "This is currently at its infancy," Bolf said, "but the technology and long-term reliability reviews with the information available shows a high level of promise."

Bolf shares information on Palo Verde's robotics improvements with his counterparts at STARS Alliance nuclear plants. The STARS member plants are Palo Verde; Callaway, in Missouri; Diablo Canyon, in California; and Wolf Creek, in Kansas. "Palo Verde shares the data and innovations with our STARS peers through various participant phone calls," Bolf said. "We have shared resources among the STARS plants, and the BOP eddy current analysis using the RevospECT system is being integrated into routine business by the vendor that STARS utilizes. We have also had requests from other utilities to share information on how we successfully use the Zephyr probes in our steam generator inspections." ⊠

Boris Bolf can be contacted at Boris.Bolf@aps.com.



Top: The Pegasys eddy current device in action. **Inset:** Eddy current presentation.

Dixon and Hafen: An update on Robotics and Plant Maintenance

V1000 manipulator vehicle

Joe Dixon – NuVision-HWM

Hubert Hafen – Wälischmiller HWM

Wälischmiller Engineering (HWM), of Markdorf, Germany, has joined forces with NuVision Engineering (NVE) to form NuVision-Wälischmiller under parent company Carr's Engineering. The NVE-HWM team develops, demonstrates, and deploys engineered remote systems and robotics to meet the high safety standards, quality requirements, and challenging demands of the nuclear industry.

HWM specializes in remote-handling and robotic solutions for hazardous applications. Since 1946, HWM has been delivering a range of remote-handling solutions, including precision manipulators, tools, and controllers, to the nuclear industry.

NVE, founded in 1971, is headquartered in Pittsburgh, Pa., with major operational facilities in Charlotte, N.C. The company delivers engineered solutions and services to its customers in the nuclear markets of commercial power, research, isotope production, and government cleanup sectors. NuVision develops, demonstrates, and deploys technology-based solutions that help extend the life and safe operation of power plants, improve new plant designs, and remediate government-owned legacy waste sites.

Joe Dixon is the robotics director at NVE. For nearly 20 years, he has provided solutions for the global nuclear industry and has conceived, designed, fabricated, deployed, and managed teams for advanced robotics, isotope production, scientific research, decommissioning, energy production, process maintenance, and remote handling. Having worked on large projects around the world, Dixon is one of the industry's leaders in remote-handling and robotics technologies.

Hubert Hafen is the chief technology officer for HWM. With more than 30 years of experience in the nuclear industry, Hafen has served as chief engineer and project manager for a large number of international remote-handling projects, such as remote-handling equipment for the decommissioning of the Greifswald nuclear power plant in Germany, the decommissioning of the reprocessing plant in Karlsruhe, Germany, planning for the remote equipment for the ITER project, and several remote-handling projects in Japan, Russia, China, the United Kingdom, France, and Germany. His ability to present clients with problem solving has made him renowned in the robotics world.

Dixon and Hafen talked recently with *Nuclear News* Editor-in-Chief Rick Michal about what is new in robotics and remote-handling systems.

Continued

Wälischmiller Telbot
powered telemanipulator

What's new in robotics and remote systems?

Dixon: The "newest" items in robotics and remote systems are, regrettably, not always applicable to the high-radiation nuclear environments that we work in. Since our industry rightfully demands that our products be safer, proven, and more reliable, we are not able to apply unproven advances that the commercial industry often does. That being said, we are careful to watch any and all developments in the industry of robotics while trying to figure out how new products can be deployed safely for high-radiation environments. Some of the more recent nuclear deployments we have been seeing and performing include increased sensitivity of force feedback controls to make the robotics feel like the operator is actually doing the work by hand; autonomous radiation mapping using highly programmed drones; advancements in the use of virtual reality in hot cell work; and 3-D cameras in low-radiation environments.

Hafen: Some additional areas I have specifically been involved with include the development of radiation-resistant electronics for projects, including ITER. This international project will produce new solutions for some extremely difficult remote-handling tasks. The maintenance of the fusion reactor will have to be completely remote operated.

Has the pandemic resulted in any work-arounds using robots/ remote systems that will become commonplace post pandemic?

Dixon: The pandemic created an increased need for automation and robotics used in production and distribution across the country. We found that all industries were affected by the fact that a large part of the nation's and the world's workforce was working from home. The growth in production robotics has been and will continue to be seen in part because of the pandemic but also due to the demands for efficiency in these industries. This is much less likely to affect our industry because of our low level of production and limited repetitive operations, although some of what was already common in our industry is currently being adapted for use in other industries. Our need for remote access, maintenance, and diagnostics is now something that is useful to the rest of the world in a pandemic environment where human interaction is discouraged.

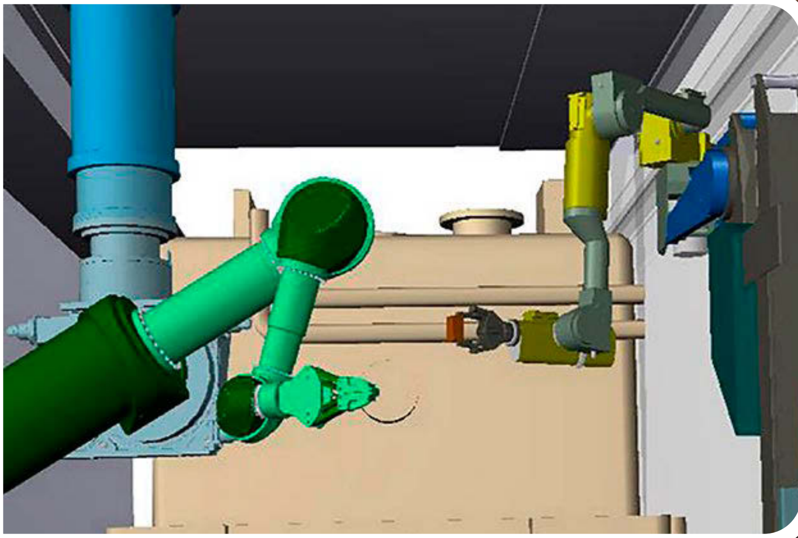
Hafen: For decades, the nuclear industry has been deploying Wälischmiller robotics to decontaminate nuclear facilities. The combination of that concept with non-radiation-tolerant sensors used in equipment such as automated vacuums have allowed some companies to develop robotics capable of autonomously decontaminating workspaces and hospitals. Being able to access the control systems from another office or someone's home allows technicians to maintain and repair equipment from anywhere in the world. NuVision-Wälischmiller has been utilizing this technique for many years now, which means that we essentially have local technicians anywhere in the world.

What are the areas in a nuclear plant where robotics improvements help the most, and where will human involvement always be needed?

Dixon: Our industry is comfortable with drawing the line for safe access for humans. Although the technology to put fully automated robotics into every aspect of the nuclear industry exists, the cost, complexity, and difficulty to recover from any potential failure make this scenario highly unlikely in our lifetimes. Designs for new nuclear facilities often try to account for all possible situations by designing in remote equipment for all the high-radiation environments.

Some facilities have opted for our force feedback manipulators, and others tend to stay with the tried-and-true A100 or A200 series of mechanical telemanipulators. If the work requires the use of tweezers and picking up sample pieces as light as a feather, the use of our human interaction on telemanipulators is usually preferred. With heavy loads, long reaches, or highly demanding decommissioning activities that are beyond the capabilities of a telemanipulator, the power manipulators are the perfect choice.

Hafen: Yes, there are areas in a nuclear plant where robotics improvements help. The robots go where it is not safe for humans. But a human will always be needed, because the tasks that we do are not standard, repetitive tasks. I view it as a symbiotic relationship where the robots can help operators, but will not replace them. It is difficult to replace a skillful operator with a cost-effective machine. Human supervision and control will always be necessary, no matter how cost-effective. Safety, and that means human involvement, will always have to be a priority due to the serious consequences that potential failure could bring.


Virtual reality technology is used for real-time monitoring.


An example of mobile robotics deployment.

Continued

A Wälischmiller Telbot is used for decommissioning work.

How are robots/remote systems improving plant maintenance?

Hafen: Facilities in our industry are becoming more and more complicated, so robots are becoming more and more sophisticated. An example of this is robotic replacement of valves with vacuum welding. So, naturally, robots, tools, and equipment should be moving in the same direction toward the ability to fulfill complex tasks. Most areas are still maintained by personnel, which means exposure to radiation. This is where robotics can come into play, using, for example, magnetic crawlers to do the inspection, which will reduce exposure to personnel. The remote-controlled vehicle like the HWM-V1000 makes it possible to maintain even those areas that were not initially designed for remote maintenance. New facilities have to consider and design for the use of robotics, or adding them later will become more expensive and challenging. So, it is important to have the media like *Nuclear News*, as well as conferences, bring the new technology possibilities to light and share the news with the design engineers.

There are videos on YouTube of a robot that can move like a human. Do you envision something like that being used in the industry someday?

Hafen: The application of humanlike robots—like an arm and a hand—is possible in low-radiation areas such as glove boxes. Still, they are not widely employed in the nuclear industry because they are not safe enough. It will take a long time until they will find application in the high-radiation nuclear sector. Also, in many cases, a humanlike robot may not be the best choice. Nature has myriad forms of living organisms to choose from, and so we do not have to be limited by the shape of humanlike robots.

Wälischmiller A1000 power manipulator

Dixon: There are certainly repetitive tasks in low-radiation areas that a humanlike robot arm could be utilized through software and mechanics. However, a robot designed to mimic the shape of an entire human is not required or optimized for existing applications in the nuclear industry. The development of cutting-edge mechanical robots like the Telbot was born from the need to put highly versatile and accurate robots within very high-radiation environments and offer greater reaches and abilities than a humanoid robotic arm could.

What is the biggest challenge to creating a robotic solution?

Dixon: There are always technical hurdles and strict specifications that must be accomplished for every project. As our equipment is used in extremely high-radiation environments in 33 countries around the world, the reality of poor performance could be front-page news. Our reputation and that of the entire industry rests on every project. That makes the safety of the workforce and the reliability and capability of our equipment the most important challenge that we must meet. To add to those complexities, with almost every project we are faced with requirements for an individual nation's quality control requirements, different electric codes, standard operation practices, and seismic analysis. All these must be clearly understood and analyzed before the first drawing begins.

Hafen: The technical risk in the implementation of solutions from other industries into the nuclear world is significant and challenging, especially when all electronic parts have to be tested to be proven reliable. The components of a robotic system can become obsolete in a short time, while the robotic system itself has to last for decades. This must always be considered during the design phases. The choice of suppliers for components influences the after-sales service. We are very proud that we have been able to keep all our systems still running over these many years.

NuVision and Wälischmiller are now sister companies. How does this partnership benefit the nuclear remote-handling and robotics supply chain?

Dixon: The union of our two companies under the Carr's Engineering group has major benefits for both companies and our customers. We are now able to offer local management, service, and sales in the United States and anywhere in the world. The addition of our remote-handling products and custom engineered solutions into the North American supply chain has made it cost-effective for our customers to have a choice of products so that they can find exactly what fits their needs. We offer very competitive prices with some of the shortest lead times in the industry, and we accomplish all of this with the highest quality products and quality controls available.

Hafen: One of the exciting aspects for me is our combined ability to bid on a wider range of projects. Many of the robotics projects that NVE-HWM competes for dwell in a very small "niche" market. Our products are designed for very high-radiation environments, and there are only a handful of companies in the world that have the ability and the track record to join in those competitions. I believe that NVE-HWM's combined products, expertise, experience, in-house design, and IT capabilities are unmatched in this arena. I also believe that these capabilities allow us to collaborate within our niche market and bid with our competitors on extremely complicated projects with multidiscipline requirements.

NRC completes final safety report for NuScale SMR design

The final safety evaluation report for NuScale Power's small modular reactor design has been issued, completing the design's technical review and approval, the Nuclear Regulatory Commission announced on August 28.

The NRC will now prepare a rulemaking to certify the NuScale design. Full certification, if granted by the commissioners following the staff's recommendation, will allow a utility to reference the design when applying for a combined license to build and operate a nuclear power plant.

"This is a significant milestone not only for NuScale, but also for the entire U.S. nuclear sector and the other advanced nuclear technologies that will follow," said John Hopkins, NuScale's chairman and chief executive officer. "This clearly establishes the leadership of NuScale and the U.S. in the race to bring SMRs to market. The approval of NuScale's design is an incredible accomplishment, and we would like to extend our deepest thanks to the NRC for their comprehensive review, to the U.S. Department of Energy for its continued commitment to our successful private-public partnership to bring the country's first SMR to market, and to the many other individuals who have dedicated countless hours to make this extraordinary moment a reality."

Hopkins also acknowledged the cost-shared funding provided by what he termed "the strong bipartisan support from Congress" over the past several years. He credited the funding with accelerating the company's advancement through the NRC's design certification process.

Headquartered in Portland, Ore., NuScale applied to the NRC in December 2016 for certification of its SMR design for use in the United States, and in March 2017 the NRC accepted the application for review.

According to the company, more than $500 million and over 2 million labor hours have been invested—with the backing of Fluor Corporation—to develop the information needed to prepare the application. NuScale said it submitted some 12,000 pages for the application, 14 separate topical reports, and more than 2 million pages of supporting information for NRC audits.

IOWA

Windstorms force early closure of Duane Arnold

High winds that caused damage across central Iowa in August prompted NextEra Energy to close the Duane Arnold nuclear power plant about two months earlier than originally planned. The plant's 622-MWe boiling water reactor had been off line since August 10, when a line of intense, fast-moving windstorms, called a derecho, caused a loss of off-site power and damaged the plant's cooling towers. NextEra had planned to permanently shut down Duane Arnold, Iowa's only nuclear power reactor, on October 30.

The company released the following statement on its decision not to restart the reactor: "After conducting a complete assessment of the damage caused by recent severe weather, NextEra Energy Resources has made the decision not to restart the reactor at Duane Arnold Energy Center. The strong storms that hit the area on August 10 caused extensive damage to Duane Arnold's cooling towers, and our evaluation found that replacing those towers before the site's previously scheduled decommissioning on October 30, 2020, was not feasible.

"As we have done since we announced the decommissioning of Duane Arnold in 2018, we will continue to work with all our employees to minimize the impact of this situation on them and their families."

FLORIDA

Investigation begun into mid-August trips at Turkey Point

The Nuclear Regulatory Commission on August 31 initiated a special inspection at Florida Power & Light's Turkey Point nuclear power plant to review three Unit 3 trips, or unplanned shutdowns, that occurred between August 17 and August 20.

According to the NRC, operators manually tripped the reactor from 92 percent power on August 17 in response to rising steam generator water levels; on August 19, Turkey Point's reactor protection system automatically tripped Unit 3 during startup when an instrument sensed higher than expected neutron activity in the reactor core; and on August 20, operators manually tripped the unit from about 35 percent power in response to the loss of the single operating steam generator feedwater pump.

The agency said that the on-site portion of the inspection was expected to last approximately one week, and that a report documenting the results was anticipated within 45 days of the inspection's completion.

"We welcome this opportunity to share the details of equipment performance and the actions operators took to keep Turkey Point in a safe condition during the recent unplanned shutdowns," said FPL spokesman Peter Robbins in response to the NRC investigation. "Turkey Point and FPL are always ready to fully cooperate with the independent experts at the Nuclear Regulatory Commission in the spirit of complete transparency."

Robbins added that "in all three cases, the reactor was shut down in a matter of seconds, and all safety systems responded as designed."

Power & Operations continues

SOUTH CAROLINA

Settlement reached over Summer equipment ownership

South Carolina's state-owned utility Santee Cooper and Westinghouse Electric Company have finalized the terms of a settlement for determining ownership of equipment associated with the Summer plant's abandoned nuclear new-build project. The settlement agreement gives Santee Cooper full ownership of, and the ability to immediately begin marketing, all nonnuclear equipment, the utility announced on August 31.

The companies will split the net sales proceeds of Summer's nuclear-related equipment, Santee Cooper said, according to these terms:

- Major non-installed nuclear equipment will be split 50-50.
- Major installed nuclear equipment—90 percent Santee Cooper, 10 percent Westinghouse.
- Other equipment that could be used in nuclear projects—67 percent Santee Cooper, 33 percent Westinghouse.
- Remaining project equipment—100 percent Santee Cooper.

"Finalizing this agreement is a tremendous milestone, because it means Santee Cooper can move quickly to sell thousands of pieces of equipment ourselves, as well as support Westinghouse's efforts to sell the nuclear equipment," said Mark Bonsall, Santee Cooper's president and chief executive officer. "We are already planning next steps, and Santee Cooper's proceeds from equipment sales will be used to shore up our rate freeze and contribute to our long-term plan to retire debt."

ENFORCEMENT

NRC proposes six-figure fine to TVA; cites two execs

In actions related to its rules involving employee protection, the Nuclear Regulatory Commission on August 24 issued a proposed civil penalty of $606,942 to the Tennessee Valley Authority, as well as an order prohibiting a senior TVA executive from NRC-licensed activities for five years and a violation notice to a second executive.

Following investigations completed in October 2019 and January 2020, the NRC concluded that two former TVA employees had been subjected to reprisals for raising concerns regarding a chilled work environment.

According to the NRC, in March 2018 an employee at the Sequoyah nuclear plant raised concerns about a chilled work environment, filing complaints with the utility's employee concerns program. In response, TVA's director of corporate nuclear licensing, Erin Henderson, filed a complaint against the employee, triggering an investigation that placed the employee on paid administrative leave, which ultimately led to the employee's resignation in August 2018.

Also in March 2018, a second TVA employee was discriminated against for raising work environment concerns, the NRC said. This employee was also placed on paid administrative leave—again, following a complaint filed by Henderson—and later terminated. In this case, TVA's vice president of regulatory affairs, Joseph Shea, "played a significant role in the decision-making process to place the former employee on paid administrative leave and terminate the former employee," according to the agency. The NRC issued the violation to Henderson and the prohibition order to Shea.

The NRC said that it is continuing to review and inspect work environment issues and TVA's corrective actions at the utility's corporate office and its three nuclear power plants—Browns Ferry, Sequoyah, and Watts Bar. As stated in the most recent annual assessment of Watts Bar, the NRC has determined that TVA has made progress in addressing these issues.

UNITED KINGDOM

Trade group debuts blueprint for lowering nuclear construction costs

The Nuclear Industry Association (NIA), the trade group for the United Kingdom's civil nuclear industry, unveiled a new report September 2 that sets out a framework for cutting the cost of building new nuclear power plants in Britain.

Authored by the New Build Cost Reduction Working Group, a cross-sector team established as part of the U.K. government–backed Nuclear Sector Deal, the report identifies the key factors to reduce risk and lower costs, including rigorously planning pre-construction activities, with simplicity of design and construction methodology; repeating designs across multiple plants; and building up and transferring a skilled and experienced workforce to new projects.

In addition, the report identifies how a new financing model that controls construction risk will bring down consumer costs by mobilizing a wider pool of investors and cutting the cost of capital, the NIA said.

Also described in the report is a comprehensive risk-assessment tool being developed by industry to monitor 14 key factors for project delivery and efficiency. According to the NIA, the tool will enable developers, investors, and the government to develop a clear understanding of project risks to support investment decisions, and then track the ongoing management of those actions and risks throughout the delivery of the project.

"I am very pleased to say that the nuclear new build cost reduction workstream has made great progress, and our report clearly shows it's possible to deliver a cost-effective program of new nuclear power stations in the U.K.," said Humphrey Cadoux-Hudson, managing director of EDF Energy and chair of the Nuclear Sector Deal's Cost Reduction Working Group. "But promises of cost reduction are not enough—in making this case, the developers of new nuclear plants are showing that we recognize the delivery risks we face and how to manage them."

The Nuclear Sector Deal was developed by the Nuclear Industry Council and agreed to by the British government and nuclear industry in June 2018. Among other things, it calls for the British government and nuclear industry to work together to reduce the cost to the consumer of future new nuclear projects by 30 percent by 2030, taking the Hinkley Point C strike price of £92.50 (about $123.50)/ MWh as a starting point.

The 27-page *Nuclear Sector Deal: Nuclear New Build Cost Reduction* can be found at niauk.org/wp-content/uploads/2020/09/New-Build-Cost-Reduction-Sector-Deal-Working-Group.pdf.

Hunterston B Unit 3 to restart soon; plant to retire earlier than expected

EDF Energy has received approval from the United Kingdom's Office for Nuclear Regulation (ONR) to restart the Hunterston B power station's Unit 3 for a limited run, according to August 27 announcements from both the company and the regulator. EDF has permission to operate the unit for up to 16.425 terawatt days (approximately six months of operation), the ONR said.

EDF also announced that Hunterston B—located in North Ayrshire, along the western coast of Scotland—will begin its defueling phase no later than January 7, 2022, more than a year earlier than the expected retirement date of March 2023. The decision, EDF said, was made following a series of executive board and shareholders meetings.

Hunterston B's Unit 3, a 490-MWe advanced gas-cooled reactor, has been off line since March 2018, following inspections that identified cracks in excess of the allowable number in the

Power & Operations continues

Workers on the fueling machine at Hunterston B. Photo: EDF Energy

graphite bricks that form the reactor core. Its companion reactor, Unit 4, a 495-MWe AGR, was taken off line in October 2018, also for cracks in the graphite core. While fewer cracks had been identified in Unit 4's core, experts predicted that the number would soon exceed the established safety limit.

In the summer of 2019, the ONR granted permission for Unit 4 to be returned to service for a period of approximately four months, leading to a continuous run from August to December of that year. At this writing, the ONR is assessing the safety case for Unit 4, and its current expected return-to-service date is September 17. Subject to regulatory approval, EDF is planning for two runs of six months for the unit.

"I am satisfied that the detailed safety justification provided by the licensee is sufficient to demonstrate that Reactor 3 can operate safely for this period of operation," said Donald Urquhart, ONR deputy chief inspector. "We applied stringent national and international standards when making our decision, have scrutinized the nature of the cracking observed in Reactor 3, and are satisfied that it will not prevent the reactor from operating safely or impede its ability to be shut down if required during this period of operation."

Commenting on the decision to initiate the plant's defueling earlier than scheduled, Simone Rossi, EDF Energy's chief executive officer, said, "I am extremely proud of all those who have run Hunterston B for more than 40 years. Today's announcement underlines the urgent need for investment in new, low-carbon nuclear power to help Britain achieve net zero and secure the future for its nuclear industry, supply chain, and workers."

CANADA

Ontario backs plan to keep Pickering operating through 2025

The government of Canada's Ontario province is supporting a plan by Ontario Power Generation (OPG) to extend the life of the Pickering nuclear power plant, the province's Ministry of Energy, Northern Development, and Mines announced in August. Currently, all six operating reactors at the facility, located in southern Ontario, are scheduled to close at the end of 2024.

Under OPG's proposed plan, Pickering-1 and -4, 515-MWe CANDU pressurized heavy-water reactors, would retire in 2024, while Units 5 through 8, 516-MWe CANDU PHWRs, would continue operating through 2025. Units 2 and 3 have been in safe shutdown since 1997.

The final decision regarding the revised schedule for Pickering will be made by the Canadian Nuclear Safety Commission (CNSC).

"The safe operation of Ontario's nuclear assets is our top priority," said Minister of Energy, Northern Development, and Mines Greg Rickford. "I'm pleased that OPG has developed an innovative proposal that will provide Ontarians with emission-free, low-cost energy and keep highly skilled Ontarians working in their communities longer."

Ken Hartwick, OPG president and chief executive officer, said, "Our extensive analysis has shown that we can safely and reliably operate

Pickering nuclear power plant. Photo: OPG

Pickering until the end of 2025 and provide a solid benefit to the ratepayer. I want to recognize every one of the Pickering staff for their commitment to safety and for their role in improving performance year over year. The station's performance is better than ever, and Ontario electricity users will continue to benefit from clean and stable baseload power for several more years."

At a Pickering license renewal hearing in 2013, OPG indicated its intention to end commercial operation at the plant in 2020. In June 2016, however, the Ontario government requested that the utility extend the operation of some units to 2024, as several reactors at the Darlington and Bruce stations would be off line for long periods while undergoing major refurbishments. In August 2017, OPG applied to the CNSC for a 10-year license renewal, which was approved the following year.

The CNSC said that its decision to approve the renewal application was based on OPG's stated 2024 shutdown date. The commission also noted that the renewed license would require OPG to present a comprehensive mid-term update on its licensed activities at the station by 2023.

FLEET PERFORMANCE

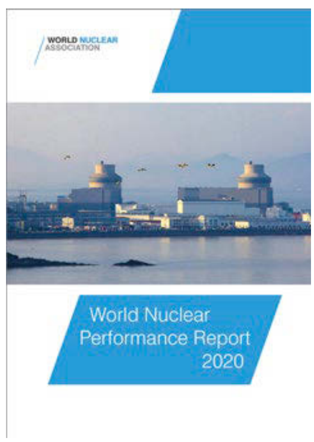
WNA: Nuclear generation in 2019 close to record high

Global nuclear power generation in 2019 totaled 2,657 TWh, second only to the 2,661 TWh generated in 2006, according to the *World Nuclear Performance Report 2020*, released August 25 by the World Nuclear Association. This is the seventh consecutive year that nuclear generation has increased, the WNA noted, with output 311 TWh higher than in 2012.

"In 2020, the world's nuclear reactors have shown resilience and flexibility, adapting to changes in demand while ensuring stable and reliable electricity supplies," said WNA Director General Agneta Rising in a press release.

The report's key findings include:

- Six reactors started up in 2019, including four large pressurized water reactors—one in South Korea, one in Russia, and two in China—and two small reactors on Russia's floating nuclear plant, the Akademik Lomonosov, harbored at Pevek, on the northeast Russian coast.
- Nuclear generation fell fractionally in North America and in Western and Central Europe, but rose in Africa, Asia, South America, and Eastern Europe and Russia. The report identified particularly strong growth in Asia, where nuclear power generation rose by 17 percent in 2019. China has more than tripled its nuclear generation in six years, from 105 TWh in 2013 to 330 TWh in 2019, and is now responsible for more than half of the nuclear generation in Asia.
- The average global capacity factor for reactors generating electricity in 2019 rose from 79.8 percent to 82.5 percent.
- More than two-thirds of the world's reactors achieved a capacity factor greater than 80 percent. This maintains the significant improvements made since the 1970s, when fewer than 30 percent achieved this level of performance.
- Five reactors reached 50 years of operation in 2019.



Power & Operations continues

■ No age-related decline in capacity factor is seen in nuclear reactor performance, with average capacity factors increasing with age for reactors between 40 and 50 years old.

■ Thirteen reactors shut down in 2019, including four in Japan that had not generated power since 2011 and three in South Korea, Germany, and Taiwan that were shut down due to phaseout policies.

■ Construction started on five reactors in 2019, two in China and one each in Iran, Russia, and the United Kingdom.

■ Median construction time for reactors starting up in 2019 was 117 months, which is above the average achieved since 2001. This is in part due to many of the reactors entering service in 2019 being first-of-a-kind units.

■ The construction of a new design need not result in a long construction time, as Yangjiang-6, the second ACPR-1000 unit to be built, was completed in 66 months.

While concluding that the performance of the world's operating reactors continued to improve in 2019, the report also emphasized that the pace of new nuclear start-ups needs to increase. "Globally, there are more than 100 nuclear new-build projects that are ready to begin," Rising said. "Each would generate thousands of jobs during construction and hundreds of jobs during 60 years or more of operation. They would help contribute to economic recovery plans and deliver the clean and reliable electricity needed to meet sustainable development goals."

UAE

First Barakah unit connected to grid

Nawah Energy Company, in cooperation with the Abu Dhabi Transmission and Despatch Company (TRANSCO), connected Unit 1 of the Barakah nuclear power plant to the United Arab Emirates' power grid in August. Barakah, located in the Al Dhafrah Region of Abu Dhabi, houses four 1,345-MWe APR-1400 pressurized water reactors. Unit 1 achieved first criticality earlier that month.

"The safe and successful connection of Unit 1 to the UAE grid marks the key moment when we begin to deliver on our mission to power the growth of the nation by supplying clean electricity, around the clock," said Mohamed Ibrahim Al Hammadi, chief executive officer of the Emirates Nuclear Energy Corporation (ENEC), Nawah's parent company, in an August 19 announcement. "Grid connection of Unit 1 really is the beginning of a new era in our project, which is built upon years of preparation and adherence to the highest international safety and quality standards. We are confident in our people and our technology to continue to progress to reach commercial operations and the completion of the remaining three units, with the goal to power up to 25 percent of the UAE's electricity needs for at least the next 60 years."

Al Hammadi also acknowledged ENEC's prime contractor and partner on the Barakah project, the Korea Electric Power Corporation, for its efforts, as well as TRANSCO, for the construction of 952 kilometers (about 590 miles) of 400kV overhead lines.

"TRANSCO plays an important role in facilitating a more sustainable energy future for the UAE," said Afif Saif Al Yafei, the company's CEO. "As the country forges ahead with utility-scale clean energy projects, TRANSCO continues to ensure these projects can effectively integrate with our existing network infrastructure to provide a secure and stable supply of power to the community. The integration of Unit 1 of the Barakah nuclear energy plant is an important step towards increasing clean energy generation capacity to the grid."

With the completion of grid synchronization, reactor operators will begin the process of gradually raising Unit 1's power levels, known as power ascension testing. The testing will be conducted under the oversight of the UAE's independent nuclear regulator, the Federal Authority for Nuclear Regulation, which has conducted more than 280 inspections since the start of Barakah's development, according to ENEC.

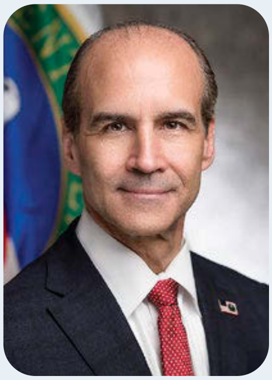
In Case You Missed It—Power & Operations


Artist's rendering of the Hinkley Point C project. Image: EDF

EDF was fined €5 million (about $5.9 million) in late July by the Enforcement Committee of the Autorité des Marchés Financiers (AMF) for providing false information about the United Kingdom's Hinkley Point C nuclear-build project. The committee also imposed a €50,000 (about $59,000) fine on EDF's former chairman and chief executive officer, Henri Proglio, in the matter. According to a July 30 AMF statement, the false information was spread via an October 8, 2014, news release.

A separate accusation by AMF regarding an alleged failure by EDF and its current CEO, Jean-Bernard Lévy, to promptly disclose in 2015 "inside information" related to Hinkley Point C was dismissed.

The AMF is described on its website as an independent public authority that regulates the French financial marketplace and its participants.


Menezes

The Senate confirmed Mark W. Menezes as deputy energy secretary on August 4 in a bipartisan 79–16 vote. Prior to his confirmation, Menezes had served as undersecretary of energy to both Secretary Dan Brouillette and his predecessor, Rick Perry.

Before joining the Trump administration in 2017, Menezes was an executive with Berkshire Hathaway Energy. He has also worked on Capitol Hill as chief counsel for energy and environment for the House Committee on Energy and Commerce, where he served as chief negotiator for the House majority in the enactment of the Energy Policy Act of 2005.

"I am honored that President Trump and the members of the U.S. Senate have placed their confidence in me to serve as the deputy secretary of energy," Menezes said. "I will continue to work alongside Secretary Brouillette to advocate for the use of all of America's abundant energy resources, broadening our supercomputing capabilities and innovation at our national labs, and providing a strong national defense through a modern and dynamic National Nuclear Security Administration."


Artist's rendering of the proposed Wylfa Newydd nuclear power plant. Image: Horizon Nuclear Power

Horizon Nuclear Power is in talks with the U.K. government to revitalize plans to build the Wylfa Newydd nuclear power plant in northwestern Wales, the *Financial Times* reported on August 15.

"What I've been trying to do over the last period is convince people that our suspension has not in any way undermined our ability to restart quickly," Horizon's chief nuclear officer, Duncan Hawthorne, told the *Times*. "We are ready to go . . . but the funding model needs to be in place. We've got a competitively priced project that will generate jobs quickly and really fuel the economy in the region the plant is in. If we can't make our transaction viable in this environment, then it's never going to happen."

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

Power & Operations continues

KAZAKHSTAN

Kazatomprom to continue reduced uranium production through 2022

Kazatomprom, Kazakhstan's state-owned uranium production company, will continue "flexing down" production by 20 percent through 2022, compared to the planned levels under subsoil use contracts, the company announced in August. It will also maintain its 20 percent reduction against subsoil use contracts in 2021, with no additional production planned to replace volumes lost in 2020 due to measures taken to combat COVID-19.

According to the announcement, Kazatomprom does not expect to return to full subsoil use contract production levels until a sustained market recovery is evident and demand and supply conditions signal a need for more uranium.

"The decision to keep production similar year-over-year and extend production curtailment into 2022 is indicative of a global uranium market that is still recovering from a long period of oversupply," said Galymzhan Pirmatov, Kazatomprom's chief executive officer. "We are simply not seeing the market signals and fundamental support needed to ramp up mine development in 2021 and take our low-cost, tier-one production centers back to full capacity in 2022.

Pirmatov added that the market's uncertainty attributed to the COVID-19 pandemic was significant and that despite the anticipated supply deficit in 2020, uranium prices and long-term contracting activity, while higher than in 2019, remain unsustainably low. Consequently, he said, in line with Kazatomprom's market-centric strategy, the company intends to continue with the level of spending and operational activity commensurate with a 20 percent reduction in subsoil use contracts that have been maintained since 2018.

The Kazatomprom CEO also warned that the company could not rule out the possibility of further production disruptions due to the pandemic, declaring the health and safety of his employees to be the top priority.

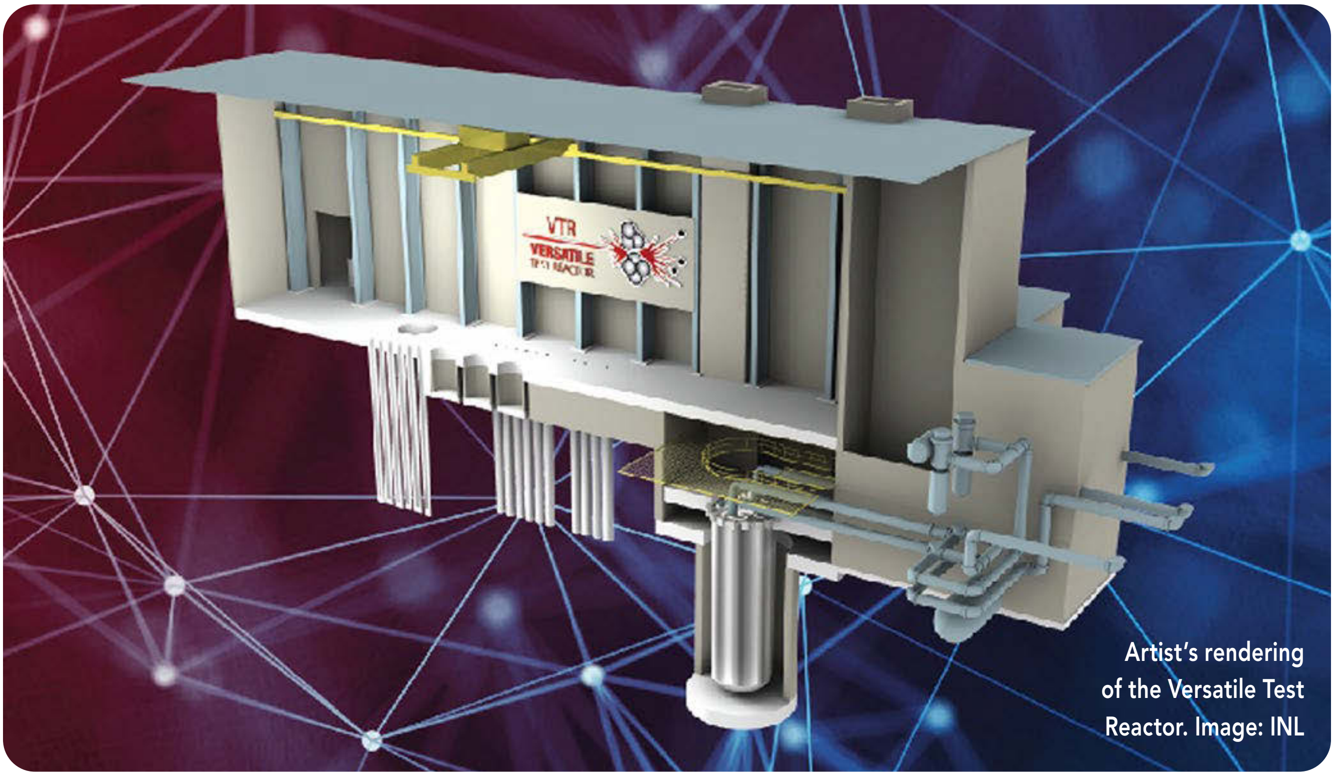
The full implementation of the decision would remove up to 5,500 metric tons of uranium from anticipated global primary supply in 2022, the company said, with uranium production in Kazakhstan staying similar with the level expected in 2021. Kazatomprom's 2022 production is therefore expected to be from 22,000 to 22,500 tU (100 percent basis), a 20 percent reduction of the total expected subsoil use contract level of about 27,500–28,000 tU.

Kazatomprom's total consolidated uranium production is expected to be reduced by over 20,000 tU (100 percent basis) from its previous 2020–2022 production plans under subsoil use contracts.

Kazatomprom is the world's largest producer of uranium, with its attributable production representing approximately 24 percent of global primary uranium production in 2019, according to the company. It operates 24 deposits grouped into 13 mining assets, all of which are located in Kazakhstan and mined using *in situ* recovery technology.

In late 2017, Kazatomprom announced that it would be decreasing its uranium production by 20 percent over the next three years, beginning in January 2018.

Kazatomprom is extending uranium production cuts. Photo: Kazatomprom



Artist's rendering of the Versatile Test Reactor. Image: INL

Negotiations to build Versatile Test Reactor under way

A team led by Bechtel National Inc. (BNI) that includes GE Hitachi Nuclear Energy (GEH) and TerraPower is in contract negotiations with Battelle Energy Alliance (BEA) for the design-and-build phase of the Versatile Test Reactor. As planned, the VTR would support irradiation testing of fuels, materials, and equipment designed for advanced reactors.

In January 2020, GEH and TerraPower submitted a joint proposal in response to a call for expressions of interest from BEA, the contractor that operates Idaho National Laboratory for the Department of Energy. INL manages the VTR project on behalf of the DOE's Office of Nuclear Energy (DOE-NE).

"We received excellent proposals from industry, which is indicative of the support to build a fast-spectrum neutron testing facility in the United States," said INL Director Mark Peters in an August 24 announcement. "We are excited about the potential for working with the BNI-led team. They will bring a lot of design and construction expertise to the VTR project. This is essential, since it has been several years since we built a test reactor in the United States."

DOE-NE established the VTR program in 2018 in response to several reports outlining the need for a fast spectrum test reactor and requests from U.S. companies developing advanced reactors. The Nuclear Energy Innovation Capabilities Act, passed in September 2018, authorized the DOE to proceed. In November 2018, GEH and its PRISM technology were selected to support the VTR program.

Since then, a team of experts from INL and five other national laboratories (Argonne National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, Pacific Northwest National Laboratory, and Savannah River National Laboratory), 19 universities, and nine industry partners have been developing a conceptual design, cost estimate, and schedule for the VTR.

The INL-led team is also supporting the development of an environmental impact statement that will be used to assist the DOE in making a final decision on the design, technology selection, and location for the VTR. That final decision is expected in late 2021 and, according to the DOE, the VTR could be completed as early as 2026.

INTEGRATED ENERGY SYSTEMS

Nuclear is up to the challenge of energy storage

The Department of Energy created the Energy Storage Grand Challenge earlier this year with the goal of accelerating the development, commercialization, and utilization of next-generation energy storage. While there is no "N" for nuclear in "ESGC," nuclear is definitely part of the DOE's plan for future energy storage technologies and integrated energy systems designed to improve the efficiency and reliability of U.S. energy markets.

Idaho National Laboratory is leading the integrated energy systems research of the DOE's Office of Nuclear Energy, and that research "seeks to maximize energy utilization, generator profitability, and grid reliability and resilience through novel systems integration and process design, using nuclear energy resources across all energy sectors in coordination with other generators on the grid," according to Shannon Bragg-Sitton, who works at INL as both the Integrated Energy Systems Lead for Nuclear Science and Technology as well as the National Technical Director, Integrated Energy Systems and DOE-NE Crosscutting Technology Development.

The deployment flexibility gained by energy storage is key to integrated energy systems. "Energy storage systems—including electrical, thermal, and chemical storage options—are expected to play a key role in managing variable grid energy demands using both variable renewable generators and thermal generators, such as nuclear energy, that have traditionally provided baseload

This rendering of a portion of DETAIL identifies the MAGNET (Microreactor Agile Nonnuclear Testbed), TEDS (Thermal Energy Distribution System), and HTSE (High-Temperature Steam Electrolysis) equipment. Image: INL

Research & Applications continues

Bragg-Sitton

electricity," Bragg-Sitton told *Nuclear News*.

A key component of DOE-NE's integrated energy systems research is to develop a flexible "ecosystem" for modeling, analysis, and optimization of integrated energy systems that can accommodate various reactor types, renewable technologies, energy storage components, and energy users, including water desalination, district heating, hydrogen production, synthetic fuels, and chemicals. "This modeling ecosystem supports optimized system design, identifying the appropriate component sizes for a specified energy application, and optimized real-time energy dispatch, whether that energy is in the form of heat or electricity, and whether that is derived from real-time generation or from stored energy sources," Bragg-Sitton said. "A lot of work is going on right now. We are installing energy storage in our laboratory for testing and demonstration in the coming year."

The integrated energy systems laboratories at INL are housed in the Dynamic Energy Transport and Integration Laboratory (DETAIL). DETAIL incorporates multiple subsystems, connecting heat and electricity producers, thermal and electrical storage, and multiple heat and electricity customers through a thermal and electrical network. Each component will be able to operate either independently or in response to the needs of the lab-scale grid.

The thermal components of the DETAIL testbed are funded by DOE-NE. They include a High-Temperature Steam Electrolysis (HTSE) system; a Microreactor Agile Nonnuclear Testbed (dubbed MAGNET), which will use electrical heating elements to emulate the heat from nuclear fuel; and a Thermal Energy Distribution System (TEDS).

"The High-Temperature Steam Electrolysis system is currently operational, and TEDS and MAGNET are being installed now," Bragg-Sitton said. "They are expected to be fully operational by December."

TerraPower and GEH pair a sodium fast reactor with heat storage

While heat storage has been proposed to improve the economics of existing light-water reactors, the Natrium design recently introduced by TerraPower and GE Hitachi Nuclear Energy (GEH) would integrate energy storage into a new build project from day one.

As described, Natrium would offer baseload electricity output from a 345-MWe sodium fast reactor with the load-following flexibility of molten salt thermal storage. Stored heat can be used to boost the system's output to 500 MWe for more than five-and-a-half hours when

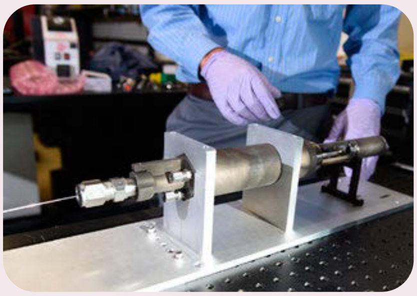
Artist's rendering of Natrium. Image: TerraPower

needed, according to TerraPower. A company representative told *Nuclear News* that the company expects a commercial Natrium plant to cost $1 billion or less.

"Our exceptional technology development capabilities, unmatched financing credibility, and achievable funding strategy mean that the Natrium technology will be available in the late 2020s, making it one of the first commercial advanced nuclear technologies," said Chris

Research & Applications continues

In Case You Missed It—Research & Applications

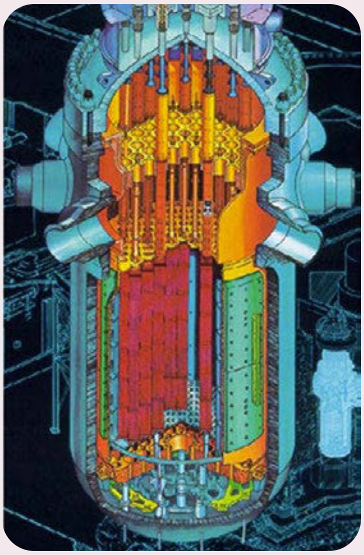


A partially assembled capsule for the MARCH system. Photo: INL

INL continues to fine-tune the testing capabilities of the Transient Reactor Test Facility, also known as TREAT, which returned to service in 2017 after a hiatus of more than two decades. To make full use of TREAT's capabilities, researchers at Idaho National Laboratory created the Minimal Activation Retrievable Capsule Holder (MARCH) test vehicle system, which, according to an August 26 Department of Energy press release, can cut years off the development process for nuclear fuels and materials and allow new clients, including NASA, to take advantage of TREAT's capabilities.

The MARCH system enables rapid analysis and permits the use of smaller test samples. According to the DOE, the key components include a specimen holder that can be tailored to deliver the desired neutron exposure, temperatures, and local thermal/cooling environment for a given experiment, and a reusable safety capsule. Small samples are placed inside the specimen holder, which is then inserted in the reusable safety capsule. That safety capsule is inserted in TREAT and irradiated.

CASL's 10-year mission is complete. The Department of Energy established the Consortium for Advanced Simulation of Light Water Reactors (CASL) at Oak Ridge National Laboratory in 2010 as a national collaboration of government, academia, and industry to help the nuclear industry extend the life of the current reactor fleet and develop more efficient next-generation reactors. In August, ORNL issued a news release and video to celebrate the achievements of CASL.

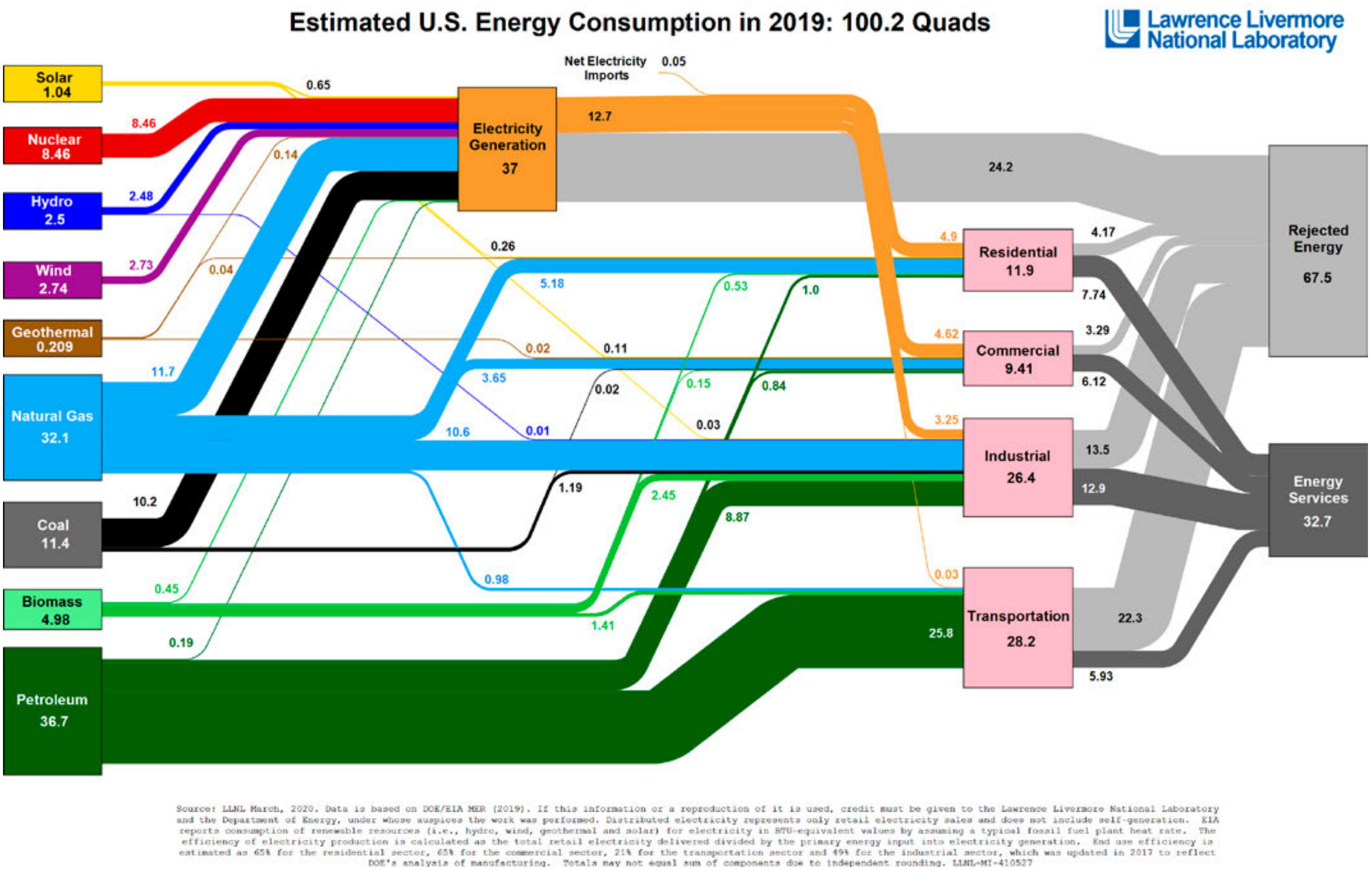


VERA's tools allow a virtual window inside the reactor core, down to a molecular level. Image: ORNL/DOE

CASL developed the Virtual Environment for Reactor Applications (VERA), a software suite based on reactor physics, thermal hydraulics, chemistry, and fuel performance that allows insight into every part of a reactor. To date, the software has been used to accurately simulate more than 200 fuel cycles, representing two-thirds of the U.S. operating reactor fleet, and has also modeled as-yet-unbuilt reactor types. VERA is now available for commercial licensing, and the first license was granted to the Electric Power Research Institute, which was involved in CASL from the beginning, in March 2020.

For insights from those involved in CASL over the past 10 years, read what ORNL has to say at ornl.gov/news/casl-wraps-10-years-solving-nuclear-problems-and-hands-toolbox-industry.

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



A full year of U.S. energy consumption and use is captured in the flowcharts released annually by Lawrence Livermore National Laboratory at flowcharts.llnl.gov. Called Sankey diagrams, the flowcharts pack a lot of quantitative data into a single-page graphic. Read from left to right, they contain information about resource, commodity, and by-product flows, and interwoven resource streams help clarify the nation's complex system of energy use.

This year, in addition to releasing the 2019 energy flowchart, the lab issued state-by-state energy flowcharts for 2015–2018 and carbon emissions charts for 2014–2017. At a glance, the state charts show the spectrum of resources each state uses to produce electricity and indicate whether a state is an electricity importer or exporter.

While the entire output of U.S. nuclear power plants currently feeds into electricity generation, a close look at LLNL's Sankey diagrams makes it easy to see a role for nuclear power in integrated energy systems that send some of that energy directly to industrial process heat customers, bypassing the grid.

Levesque, TerraPower's president and chief executive officer.

Natrium, which gets its name from the Latin for sodium, is designed to integrate into power grids with high penetrations of renewables, follow the daily electric load, and take advantage of peaking prices. The molten salt thermal storage technology that makes it possible is already in use at utility-scale solar thermal plants.

Both TerraPower and GEH have experience designing and developing sodium fast reactors. "The Natrium system combines molten salt energy storage with the best of the Traveling Wave Reactor and PRISM technologies, along with additional innovations and improvements," according to TerraPower.

Nonnuclear mechanical, electrical, and other equipment would be housed at a distance from the reactor and in separate structures that could be built to industrial standards rather than nuclear standards, reducing costs. The design would reduce the amount of nuclear-grade concrete by 80 percent compared to large reactors, according to TerraPower.

To get the reactor's heat to energy storage and electricity generation, Natrium makes use of three heat transport fluids: liquid metal sodium, molten nitrate salt, and water. According to TerraPower, in the primary system the sodium-cooled nuclear core produces heat that is transferred to the molten salt through a heat exchanger. The molten salt flows from the nuclear island to the energy island where the hot salt may be stored or directly supplied to the steam generation system. The steam generation system then produces high-pressure, superheated steam that the turbine/generator converts to electrical power.

TerraPower, GE Hitachi, and Bechtel have submitted a proposal based on Natrium technology for the Department of Energy's Advanced Reactor Demonstration Program (ARDP).

According to TerraPower, Energy Northwest and Duke Energy have both expressed their support for the commercialization of Natrium through the ARDP. The project also has the backing of PacifiCorp, a subsidiary of Berkshire Hathaway Energy. TerraPower's founders include Bill Gates, who serves as chairman of the board.

FUSION

DOE grants $29 million for fusion energy R&D

The Department of Energy announced on September 2 that it has issued $29 million in funding for 14 projects as part of its Galvanizing Advances in Market-aligned fusion for an Overabundance of Watts (GAMOW) program, which is jointly sponsored by the department's Advanced Research Projects Agency–Energy (ARPA-E) and the Office of Science–Fusion Energy Sciences (SC-FES).

According to the DOE, GAMOW teams will work to close multiple fusion-specific technological gaps that will be needed to connect a net-energy-gain "fusion core," once it is ready, to a deployable, commercially attractive fusion system.

A list of the 14 GAMOW projects and their descriptions can be found online at arpa-e.energy.gov/?q=document/gamow-project-descriptions. ⊠

DOE ends dispute with South Carolina on Pu removal

The Department of Energy has reached a settlement with the state of South Carolina to remove 9.5 metric tons (t) of plutonium from the state, the agency announced on August 31. Under the settlement, which resolves litigation over the storage of surplus plutonium at the Savannah River Site near Aiken, S.C., the state will receive an upfront lump sum of $600 million in economic and impact assistance payments. In return, the DOE will be allowed more time (through 2037) to remove the plutonium from the state without the threat of lawsuits.

The settlement stems from the DOE's termination of the Mixed Oxide (MOX) Fuel Fabrication Facility in 2018. The MOX facility was intended to meet a nonproliferation agreement between the United States and Russia to dispose of 34 t of weapons-grade plutonium by converting it to nuclear fuel for commercial power reactors. Reported to be 70-percent completed when construction was halted, the MOX facility was approximately $13 billion over budget and 32 years behind schedule, according to the DOE.

The DOE is working to remove plutonium stored at its Savannah River Site. Photo: Wikimedia Commons

Following the cancellation of the MOX project, the state of South Carolina sued the DOE in an effort to prevent the facility from being shut down and, consequently, making the state a "permanent repository for defense plutonium." That lawsuit, filed in 2018, was dismissed early this year after the U.S. Supreme Court in 2019 declined to hear the case.

As part of 2002 legislation concerning the MOX facility, the DOE agreed that if its MOX fuel production goals were not met and the plutonium was not removed by a certain deadline, the department would reimburse South Carolina in the amount of $1 million per day for each day that certain milestones went unmet, up to a maximum of $100 million per year.

Currently, 9.5 t of plutonium brought into the state for the MOX facility remain in South Carolina. The next statutory deadline for removal is January 1, 2022. The DOE said that its current use of the "dilute and dispose" method of removing the plutonium, while proven to be safe and effective, guarantees that it will miss that deadline.

The current timeline projects that the 9.5 t of plutonium will be completely removed by 2049, which means that without the settlement agreement, the federal government would be subject to economic and impact assistance payments of more than $2 billion, according to the DOE.

Dilute and dispose

Separately, the DOE's National Nuclear Security Administration announced in the August 28 *Federal Register* its decision to dispose of an additional 7.1 t of non-pit plutonium using the dilute and dispose method. The plutonium would be disposed of as contact-handled transuranic (TRU) waste at the Waste Isolation Pilot Plant in New Mexico.

In an April 2015 environmental impact statement (*Surplus Plutonium Disposition Supplemental Environmental Impact Statement* DOE/EIS–0283–S2), the NNSA evaluated alternative methods of disposing of 13.1 t of surplus plutonium, comprised of 6 t of non-pit plutonium and 7.1 t of pit plutonium. In December 2015, the NNSA announced that its preferred alternative for the non-pit plutonium was preparation at the Savannah River Site and disposal at WIPP using the dilute and dispose method. At the time, the NNSA did not state a preferred alternative for disposing of the remaining pit plutonium or the options for pit disassembly and conversion.

According to the NNSA's announcement, the decision to dispose of the 7.1 t of non-pit plutonium as TRU waste at WIPP will allow the DOE and the NNSA "to prepare more plutonium in a shorter time for disposition, thereby accelerating removal of plutonium from the state of South Carolina."

DOE to ship Savannah River waste to Texas under new HLW interpretation

The Department of Energy's demonstration case of how it applies its interpretation of high-level radioactive waste is set to go forward, as the department issued an environmental assessment (EA) report, *Final Environmental Assessment for the Commercial Disposal of Defense Waste Processing Facility Recycle Wastewater from the Savannah River Site* (final EA), and a finding of no significant impact (FONSI) for the disposal of the waste at an off-site facility.

Based on the final EA, the DOE intends to ship up to 8 gallons of recycle wastewater from the Savannah River Site's Defense Waste Processing Facility (DWPF) to the Waste Control Specialists disposal facility in Andrews County, Texas, starting within the next 12 months. Under the final EA, up to 10,000 gallons of DWPF recycle wastewater may be disposed of at a licensed facility outside of South Carolina.

The DOE published in June 2019 a revised interpretation of the statutory term "high-level radioactive waste" that classified the waste based on its radiological contents rather than the origin of the waste. The DOE determined that some defense-related waste from the reprocessing of spent nuclear fuel may be classified as non-HLW and may not require disposal in a deep geologic repository.

The final EA documents that the 8-gallon quantity of DWPF recycle wastewater, which was generated from the vitrification of high-level reprocessing waste, meets the DOE's criterion for non-HLW under its revised interpretation. The DOE's characterization analysis shows that the DWPF recycle wastewater is anticipated to be Class B low-level radioactive waste. Prior to disposal, the wastewater would be mixed with grout to solidify and stabilize the waste.

The final EA and FONSI can be found on the DOE's High-Level Radioactive Waste Interpretation web page, at energy.gov/em/program-scope/high-level-radioactive-waste-hlw-interpretation.

Waste Management continues

An aerial view of the Salt Waste Processing Facility, which has been approved for operations at the Savannah River Site. Photo: DOE

Salt Waste Processing Facility at SRS approved for start

The Department of Energy approved the start of operations at the Salt Waste Processing Facility (SWPF) at the Savannah River Site, authorizing hot (radioactive) operations to begin at the facility, the agency announced on August 17.

The approval comes five months ahead of the current baseline completion date of January 31, 2021. Parsons Corporation, which designed and built the first-of-a-kind facility, will operate it for one year.

"This is a considerable achievement for EM's [Environmental Management] cleanup program and will drive significant progress in treating the tank waste at SRS in the next decade," said William "Ike" White, senior advisor for EM to the undersecretary for science.

The SWPF is the last major piece of the liquid waste system at SRS and will process the majority of the site's salt waste inventory by separating the highly radioactive waste—mostly cesium, strontium, actinides, and waste slurry—from the less radioactive salt solution. After the initial separation process is completed, the concentrated high-activity waste will be sent to SRS's Defense Waste Processing Facility. The decontaminated salt solution will be mixed with cement-like grout at the nearby Saltstone Facility for disposal on site. Removing salt waste, which fills more than 90 percent of tank space in the SRS tank farms, is a big step toward emptying and closing the site's remaining 43 high-level waste tanks.

"SWPF provides the final piece enabling completion of tank closure activities at SRS," said Mike Budney, manager of DOE's Savannah River Operations Office.

According to the DOE, the SWPF remains on track to start normal operations later this year following completion of hot commissioning. By 2030, it is expected that nearly all of the salt waste inventory at SRS will be processed, according to the DOE.

Waste Management continues


UNDERWATER
CONSTRUCTION CORPORATION
UCCDIVE.COM | (800) USA-DIVE
The Worldwide Leader In
NUCLEAR DIVING
FOR MORE THAN 50 YEARS
LEVERAGE THE UCC ADVANTAGE
Unparalleled Support for
COMMERCIAL & GOVERNMENT FACILITIES
Committed to Nuclear Excellence
24/7 Emergent Support
Global Response Capabilities
Exceptional Safety Record
Nuclear Staff Augmentation
Innovative Underwater Solutions
Unmatched In-water Experience
ASME Section IX & XI Safety Related Welding
UCC Advanced Underwater Coatings
NACE CIP I, II, and III Inspectors
GLOBAL CAPABILITIES AND REGIONAL OFFICES
CONNECTICUT MICHIGAN SOUTH CAROLINA TENNESSEE TEXAS WISCONSIN

DECOMMISSIONING

Florida PSC clears way for accelerated Crystal River-3 D&D

The Florida Public Service Commission voted unanimously on August 18 to approve Duke Energy Florida's plan to accelerate the decontamination and decommissioning of its Crystal River-3 nuclear power plant. The commission vote marks the final regulatory approval needed to finalize, in October, Duke Energy's contract with Accelerated Decommissioning Partners (ADP). According to Duke Energy, ADP will complete the decommissioning by 2027, rather than the 2074 date that was originally announced.

Duke Energy permanently ceased operations at Crystal River-3 in 2013 and, in June 2019, the company applied to the Nuclear Regulatory Commission to transfer the reactor's license to ADP, a joint venture of NorthStar Group Services and Orano Decommissioning Holdings. The NRC approved the license transfer in April. NorthStar will also be contracted to demolish the permanently shut down coal-fired Crystal River-1 and -2.

According to the Florida PSC, the contract with ADP will lock in the cost of decommissioning Crystal River-3 at $540 million, which will be covered by the reactor's decommissioning trust fund. As of April 30, 2019, Crystal River-3 had approximately $731 million in its trust fund, according to a revised post-shutdown decommissioning activities report that ADP submitted to the NRC last year.

Duke has been ordered by the PSC to provide quarterly D&D reports through the final period of partial NRC license termination, allowing the commission to monitor decommissioning activities and the status of the decommissioning trust fund.

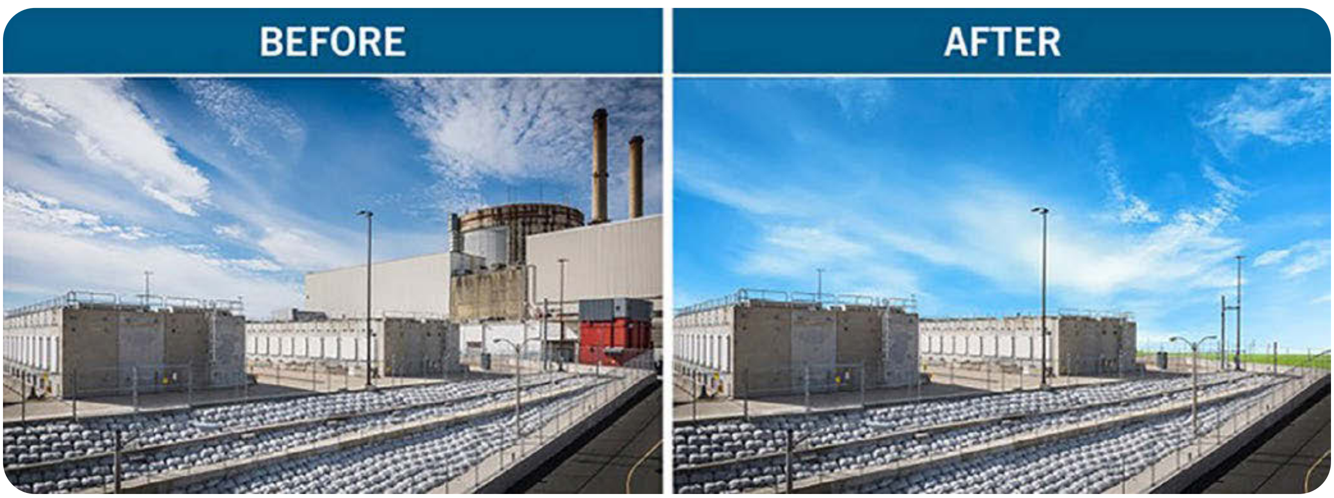
Under its agreement with ADP, Duke Energy will remain the owner of the nuclear power plant, property, and equipment, and will retain ownership and control of the decommissioning trust fund. ADP will become the NRC licensee responsible for decommissioning the plant in compliance with all state and federal regulations.

Duke Energy said that while the near-term decommissioning activities will take seven years to complete, the bigger-picture project extends 18 years, as follows:

2020-2027: ADP will decontaminate equipment, remove components, ship radioactive materials (such as the reactor vessel) to a licensed facility, demolish plant buildings, shrink the regulated land area, and seek a partial-license termination from the NRC.

2020-2037: ADP will operate and maintain the on-site independent spent fuel storage facility (ISFSI). Twenty-four-hour security, emergency response, and radiological and environmental

Crystal River-3 as it is now and how Duke Energy envisions the site will look by 2027. Image: Duke Energy



monitoring programs will continue throughout the decommissioning and ongoing operation of the ISFSI in compliance with applicable regulations.

2037-2038: ADP will restore the site and ask the NRC to terminate the license and release the property for unrestricted use. This phase assumes that the Department of Energy has taken ownership of the used nuclear fuel, and that all fuel has been moved from the nuclear plant and the ISFSI has been demolished. At that point, the property would return to Duke Energy for the company's reuse.

In Case You Missed It—Waste Management

A decommissioning contract for Fort Belvoir's SM-1 reactor was awarded to the joint venture APTIM AECOM Decommissioning, of Alexandria, Va., the U.S. Army Corps of Engineers (USACE) announced on August 28. The contract, worth about $68 million, is for the final decommissioning, dismantling, and disposal of the deactivated SM-1 nuclear power plant, located at Fort Belvoir in Virginia. SM-1 was the U.S. Army's first nuclear reactor and the first facility in the United States to provide nuclear-generated power for a sustained period to the commercial grid. Decommissioning crews are expected to begin mobilizing in early 2021, and the work is anticipated to take about five years to complete, according to the USACE.

The SM-1 nuclear power plant at Fort Belvoir in the 1960s.

Work to increase WIPP's underground ventilation has begun as work crews began excavation of a utility shaft at a location west of the Waste Isolation Pilot Plant near Carlsbad, N.M., the Department of Energy's Office of Environmental Management announced on September 1. The project to sink the shaft will cost $75 million and will be integral to increasing ventilation to WIPP's underground work area, according to the DOE.

A bucket of dirt is lifted out of the utility shaft that is being excavated at WIPP. Photo: DOE OEM

With the Yucca Mountain project being opposed by both presidential candidates, David Klaus writes in the *Bulletin of the Atomic Scientists* that "it is time for everyone else to accept that Yucca Mountain is finally off the table, and for the United States to begin to seriously consider realistic alternatives for safely managing the more than 80,000 tons of spent nuclear fuel currently sitting at 72 operating and shutdown commercial nuclear reactor sites across the country." Klaus's commentary, "If Trump and Biden agree there shouldn't be a nuclear waste site at Yucca Mountain, can't we all?" can be found online at thebulletin.org.

Bulletin of the Atomic Scientists

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

ANS Distinguished Service Award renamed to honor Levenson

Thanks to a generous donation from Margaret S. Y. Chu, a member of the American Nuclear Society since 2000, the ANS Distinguished Service Award will now honor Milton Levenson, ANS past president (1983–1984) and Fellow who died in 2018. Chu's career path intersected with Levenson many times over a 13-year span through their work as consultants. Following his death, Chu wanted a way to honor the man she described as "an extraordinary scientist who dedicated over 70 years of his life to nuclear energy."

Levenson

"Milt was admired by colleagues for his innovative approach to solving complicated problems and for his honesty, integrity, and passion for science," said Chu, managing director of M.S. Chu & Associates in New York City. "I was always awestruck by the breadth and depth of his knowledge and his unusual ability of cutting to the chase of complicated issues."

Levenson was an ANS member for more than 50 years and was elected in 1983 as the Society's 29th president. He had a long and successful 73 years in the industry, beginning his work experience at Oak Ridge National Laboratory in 1944, mostly focused on nuclear reactor safety and fuel processing.

Levenson served as a research engineer as part of the Manhattan Project at Oak Ridge from 1944 to 1948; during part of that time (1944–1946) he was also in the U.S. Army. In 1948, he moved to Illinois to work at Argonne National Laboratory, where he retired as associate laboratory director in 1973.

Levenson then moved to the Electric Power Research Institute in Palo Alto, Calif., where he served as the first director of the nuclear power division, a post he held until 1980. From 1981 to 1988, he served as executive consultant to Bechtel Power Corporation and became vice president of Bechtel International in 1984, a position he kept until 1989. In 1990, he began work as a private executive consultant and ended his career as a senior technical advisor to the weapons safety program of the National Nuclear Security Administration.

It was in that capacity that Levenson and Chu crossed paths. Chu said that she first met him in 2002 when she was director of the Department of Energy's Office of Civilian Radioactive Waste Management. From 2005 until Levenson's death in 2018 at age 95, they often worked together on various projects as consultants.

The ANS Milton Levenson Distinguished Service Award recognizes ANS members who have contributed in an outstanding manner to the vigor of the Society or who have made outstanding nontechnical contributions to the nuclear field. Such contributions might include development and understanding or extension of the goals and policies of the Society, outstanding leadership in and for the Society, or other nontechnical contributions to the Society's aims in any area.

The first recipient of the newly renamed award is Kevin R. O'Kula. An official announcement will be made during the 2020 ANS Virtual Winter Meeting, which begins November 16.

Black racial justice webinar kicks off DIA series

The Diversity and Inclusion in the American Nuclear Society (DIA) Committee opened its new series of webinars on September 2 with a panel discussion, "Black Racial Justice in the Nuclear Community."

The five panelists discussed racial justice issues and their own experiences throughout their lives in the webinar, which was viewed by more than 200 people. Included on the panel were Warren "Pete" Miller, former Department of Energy assistant secretary for nuclear energy; Michelle Scott, DOE senior advisor; Charlyne Smith, PhD candidate at the University of Florida; Ira Strong, legacy engineer at the Palo Verde plant in Arizona and a student at the University of New Mexico; and Sola Talabi, senior consultant at Pittsburgh Technical.

The roundtable was co-moderated by Lane Carasik, DIA chair and assistant professor at Virginia Commonwealth University, and Lisa Marshall, past ANS board member and DIA co-vice chair.

"ANS members really need to hear from our community members who are heavily impacted by racism and bigotry that occurs within the nuclear community," Carasik said. "For a lot of ANS members, this webinar was likely their first time hearing the difficulties that Black people of color encounter in our field at different career stages and in varying sectors. It shows we are just getting started in addressing systemic issues within our own 'house'."

The webinar opened with addresses from ANS President Mary Lou Dunzik-Gougar and ANS Executive Director/CEO Craig Piercy.

"It's very important given recent events that ANS recognizes the issues that come with racial injustice because it is relevant in all communities, including the nuclear community," Dunzik-Gougar said in her opening statement. "This webinar is a first step in helping us learn more about how to do better."

Carasik

Marshall

Piercy began his comments listing some of the African-American victims of recent high-profile violent incidents—George Floyd, Breonna Taylor, Ahmaud Arbery, and Jacob Blake.

"We know these names by heart now," Piercy said. "They symbolize the persistent and insidious threat of racism that still exists throughout our society today. As a charitable organization founded for the public good, the Society has an affirmative responsibility to combat racism, promote diversity, and practice inclusion in our community."

The DIA was already planning activities to address racial injustice prior to this summer, according to Marshall, when Floyd's killing sparked a series of protests across the country.

"This incident and subsequent ones heightened our call to action," said Marshall, director of outreach, retention, and engagement at North Carolina State University. "At the same time, Pete Miller wanted to have a roundtable. Craig Piercy and others brought us together and we started to plan for this event."

Marshall said the objective for the webinar and other events still in the planning stage is to hear first-person accounts from fellow members on this topic. But hearing them isn't enough.

"Ultimately, we want ANS and its members to take meaningful action," Marshall said.

A recording of the webinar is available for online viewing at ans.org/webinars/view-racialjustice/.

ANS News continues

RP3C Community of Practice installments feature speakers from Oklo, NuScale

Cochran

Bristol

Caroline Cochran, chief operating officer of Oklo Inc., and Sarah Bristol, PRA supervisor at NuScale Power, have given presentations recently for the American Nuclear Society's Risk-informed, Performance-based Principles and Policy Committee (RP3C) Community of Practice (CoP).

The RP3C, a special committee of the ANS Standards Board, launched the CoP in February to support risk-informed, performance-based (RIPB) methods in ANS standards. The CoP provides an opportunity to share knowledge outside of the normal management and project process. CoPs are used frequently by organizations to help break down barriers that impede the flow of information.

Cochran shared Oklo's experience in the development of the Aurora, the company's advanced fission plant concept, during her August 28 presentation, "Oklo RIPB Methods: Benefits and Challenges." The Nuclear Regulatory Commission accepted for review Oklo's combined license application on June 15.

Bristol gave a presentation on July 28 that provided lessons learned during NuScale's design certification process. NuScale received a final safety evaluation report from the NRC on August 28.

All of the RIPB CoP presentations, including the ones by Cochran and Bristol, are available on the RP3C's webpage at ans.org/standards/rp3c.

The purpose of the RP3C CoP is to support knowledge sharing on the development and application of RIPB principles and practices within the nuclear industry. The CoP holds online collaboration meetings on the last Friday of every month, beginning at 3 p.m. Eastern.

A public RIPB CoP webpage via ANS Collaborate is open to all professionals interested in RIPB principles and practices. ANS members and others can visit the webpage for details about upcoming meetings and can choose to join the group to receive notifications and be included in ongoing discussions.

Individuals interested in the CoP or in the RP3C are encouraged to contact standards@ans.org with any questions.

New Members

The ANS members and student members listed below joined the Society in August 2020.

Alderfer, Mark, Day & Zimmermann

Burkhardt, Earle, Oak Ridge National Laboratory

Chang, Szu-Li, National Tsing Hua University (Taiwan)
Chazell, Russell E., U.S. Nuclear Regulatory Commission
Cravey, Kristopher, Day & Zimmermann

Di Fulvio, Angela, University of Illinois at Urbana Champaign

Dunaway, Jason, Day & Zimmermann

Gaffney, Anne Mae, Idaho National Laboratory
Geier, Bernie J., Tennessee Valley Authority
Granados, Ricard

Helling, David W., Westinghouse Electric Company
Hidden, Fred, U.S. Department of Energy
Hindera, David, GE Hitachi
Hoelzel, Diane, KeySource Global

Howe, James, Centrus

Janikowski, Daniel Steven, Plymouth Tube
Jarrett, Matthew

Koenig, David, Southern Nuclear Operating Company

Landais, Patrick, French Alternative Energies and Atomic Energy Commission
Lathem, Lauren, Southern Company
Ledoux, Robert J., U.S. Department of Energy Advanced Research Projects Agency–Energy

McCormick, John, Day & Zimmermann
Molinda, John

Mouche, Peter A., Oak Ridge National Laboratory

Narabayashi, Tadashi, Tokyo Institute of Technology (Japan)
Nitta, Christopher, NuScale Power

Oates, Berta, High Desert Consulting Services

Pahissa-Campa, Jaime, International Nuclear Societies Council (Argentina)
Peng, Yan, China Institute of Atomic Energy
Pietrzyk, Mary, Nuclear Energy Institute

Reed, Pamela A., Framatome

Rolph, Ronald G., U.S. Nuclear Regulatory Commission

Seemann, Rebeka, Energy Northwest
Stedman, Cahlor, Xcel Energy

Tanaka, Takanori, Radioactive Waste Management Funding and Research Center (Japan)
Troc, Brandon, Fire & Pump Service Group

Votaw, Daniel, Los Alamos National Laboratory

Walcheski, Robert, Greenman Pedersen-Underwater Engineering Services

Zobin, David, Daystar Technologies

STUDENT MEMBERS

Embry-Riddle Aeronautical University
Troxler, Casey

George Washington University
Walusiak, Benjamin

Georgia Institute of Technology
Hughes, Mary E.

Idaho State University
Condie, Jason

Iowa State University
Schroer, Matthew R.

Kansas State University
Alford, Branden I.

Massachusetts Institute of Technology
Mandal, Mriganka

North Carolina State University
Batikh, Akram S.
Dallura, Vincent A.
Mast, Jacob T.
Wells, May

Ohio State University
Mallmann Paganin, Tomás

Oklahoma State University
Rose, Hunter A.

Oregon State University
Bozeman, Scott

Paul Scherrer Institute
Colldeweih, Aaron W.

Purdue University
Owen, Dulus

Rensselaer Polytechnic Institute
Kim, Junyung
Yilgor, Ilyas

Texas A&M University
Ayala, Izzy
Bayne, Christopher E.
Britton, Ryleigh E.
Butler, Kyle B.
Caldwell, Zachary
Cerezo, Seray N.
Coffman, Timothy A.
Guest, Collin
Hart, James L.
Hurst, Cameron B.
Kistle, Hadyn M.
Le, Tu
Lenox, Scott W.
Mendleski, Robert H.
Mendoza, Mario
Walls, Mason S.
Zabava, Kimberly

The University of Texas at Austin
Barlow, John E.

University of the West of Scotland
Taher, Zaid

U.S. Navy
Marple,William J.

U.S. Air Force Academy
Bayless, Benjamin

University of Michigan–Ann Arbor
Blackwood, Henry
Gordon, William
Sun, Di

University of Missouri–Columbia
Korol, Mark

University of Nevada–Las Vegas
Ayalew, Kaleab

University of New Mexico
Doan, Phat Duc

University of Pittsburgh
Sheikh, Raza

University of Puerto Rico at Mayaguez
Acevedo, Calleb J. D.
Chevres Fernandez, Lee R.
Cruzado Ruiz, Alejandro M.

University of South Carolina
Reynolds, Jason

University of Tennessee
Their, Ryan C.

University of Wisconsin–Madison
Beckman, Catherine

Virginia Polytechnic Institute & State University
Zargham, Aryana

Washington State University
Beasley, Alyssa
Premo, Virginia

Industry

NOTE: *Nuclear News* publishes news about nuclear industry contracts—but only about contract awards. We generally do not publish announcements that the work is under way or announcements that the work has been completed. Send your new contract award announcements to: Industry Editor, *Nuclear News*, 555 N. Kensington Ave., La Grange Park, IL 60526; fax 708/579-8204; email nucnews@ans.org.

BUSINESS DEVELOPMENTS

Cameco, Bruce Power collaborating on next-generation technologies center

Cameco and **Bruce Power** announced on August 20 a series of initiatives, highlighted by the creation of a center for next-generation nuclear technologies. The Nuclear Innovation Institute's Centre for Next Generation Nuclear Technologies will identify post-COVID economic, environmental, and health care opportunities. The new center will focus on next-generation nuclear technologies by advancing the existing expertise of suppliers, regulators, and operators to support future economic, environmental, and export opportunities for Ontario, Saskatchewan, and beyond. Innovations in nuclear energy will help support new technologies such as small modular reactors, cancer-fighting isotopes, and hydrogen development by using infrastructure investments. The companies also announced an additional supply of 1,600 specialized fuel bundles for Bruce Unit 6, scheduled for restart in 2024 as part of the Bruce Power Life-Extension Program.

■ **Lightbridge Corporation** announced on August 24 that it has received a notification of patent grant from the Korean Intellectual Property Office for a divisional patent application relating to a coextrusion method of manufacturing Lightbridge four-lobe helically twisted metallic fuel rods, based on its 2011 Patent Cooperation Treaty patent application.

CONTRACTS

Framatome to provide field instrumentation for Hinkley Point C EPRs

France-based **Framatome** has signed a contract with Hinkley Point C to supply conventional field instrumentation for the two European pressurized reactors under construction at the nuclear power station located in Somerset, England, the company announced on August 25. Approximately 10,000 instruments will monitor and measure temperature, flow, pressure, and level under all operating conditions. Framatome is already contracted to supply the nuclear instrumentation for the Hinkley Point C steam supply system. This new contract expands on Framatome's work to include the design, manufacturing, procurement, preassembly, installation, and qualification of the field instruments.

■ U.S.-based **Ultra Safe Nuclear Corporation** (USNC) has contracted with U.K.-based **Howden** to design a helium circulator for use in the company's micro-modular reactors (MMRs), USNC announced on August 12. USNC will collaborate with the Howden engineering and design team to maximize heat-transfer efficiencies. The company plans to incorporate the Howden submerged blower into the MMR project at the Chalk River Laboratories site in Ontario. The project is in the third stage of Canadian Nuclear Laboratories' (CNL) four-stage process to site a demonstration small modular reactor at Chalk River, a site owned by Atomic Energy of Canada Limited and operated by CNL. The USNC MMR project consists of two plants: the nuclear plant that generates heat, and the adjacent power plant that converts heat into electricity or provides process heat for industrial applications.

■ **Charah Solutions** announced on August 24 that its Allied Power division has signed a multiyear contract extension for nuclear maintenance and technical services with **Exelon Generation Company**, the largest owner and operator of nuclear plants in the United States and the largest producer of emissions-free energy. Allied Power will provide maintenance and modification services for 21 units across 12 Exelon nuclear plants in four states as well as fleetwide staff augmentation services through mid-August 2025, with an option for a five-year renewal.

ACTIONS

Standard published

The following standard has been published:

■ ANSI/ANS-18.1–2020, *Radioactive Source Term for Normal Operation of Light Water Reactors* (revision of ANSI/ANS-18.1–2016).

This standard provides a set of typical radionuclide concentrations for estimating the radioactivity in the principal fluid systems of light-water reactors and for projecting the expected releases of radioactivity from nuclear plants. It is not intended that the values be used as the sole basis for design but in environmental reports and elsewhere where expected operating conditions over the life of the plant would be appropriate.

Standard approved

The following standard has been approved:

■ ANSI/ANS-57.8–2020, *Fuel Assembly Identification* (revision of ANSI/ANS-57.8–1995; R2017).

This standard provides requirements and detailed information for uniquely identifying nuclear fuel assemblies/elements and the corresponding fuel plates or rods inside the assemblies. Detailed recommendations and requirements are provided for the numbering of the geometric orientation for the fuel plates, or fuel rods, inside the fuel assemblies.

Comments requested

Comments are requested on the following standard by October 12, 2020:

■ ANS 10.8-2015 (R202x), *Non-Real-Time, High-Integrity Software for the Nuclear Industry—User Requirements* (reaffirmation of ANSI/ANS-10.8–2015).

This standard addresses the requirements for using high-integrity, non-real-time software. High-integrity software includes safety analysis, design, simulation, and other software that can have critical consequences if errors are not detected but is so complex that typical peer reviews are not likely to identify errors. It is intended to address the type of software developed under ANS-10.7 and may be used for other software that can have critical consequences.

Comments are requested on the following standards by October 26, 2020:

■ ANS-2.2–2016 (R201x), *Earthquake Instrumentation Criteria for Nuclear Power Plants* (reaffirmation of ANSI/ANS-2.2–2016).

This standard specifies the required earthquake instrumentation used for the recording of seismic data and the evaluation of the possible effects after a seismic event for the site and Category I structures of light-water–cooled and land-based nuclear power plants. It may be used for guidance at other types of nuclear facilities. This standard does not address the

Volunteer support needed

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

■ ANS-2.32, *Guidance on the Selection and Evaluation of Remediation Methods for Subsurface Contamination* (development of new standard).

■ ANS-2.35, *Guidelines for Estimating Present and Projecting Future Socioeconomic Impacts from the Construction, Operations, and Decommissioning of Nuclear Sites* (development of new standard).

■ ANS-56.1, *Containment Hydrogen Control* (development of new standard).

■ ANS-56.2, *Containment Isolation Provisions for Fluid Systems after a LOCA* (historical revision of ANS-56.2–1989 [W1999]).

following: (a) instrumentation to automatically shut down a nuclear power plant at a predetermined ground acceleration and (b) procedures for evaluating records obtained from seismic instrumentation and instructions for the treatment of data.

■ ANS-2.23–2016 (R201x), *Nuclear Power Plant Response to an Earthquake* (reaffirmation of ANSI/ANS-2.23–2016).

This standard provides criteria that the owner of a nuclear power plant can adopt to prepare for, and respond to, a felt earthquake at the plant(s), including the need for plant shutdown, assessment of damage, and actions to determine the readiness of the plant to resume operation and to verify the long-term integrity of the plant. The criteria consider the level of any observed damage and the severity of a felt and recorded earthquake in defining a rational, experience-based approach to determine the damage potential of an earthquake and the actions needed to demonstrate the readiness of a plant to restart.

All published standards can be ordered through Techstreet at techstreet.com/ans or 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.

How premature reactor retirements might affect the United States nuclear waste disposal program

By James Conca

Nuclear power has accounted for about 20 percent of electricity generated in the United States each year since 1990. But even with climate concerns and a worldwide movement to reduce CO_2 emissions, the market is not rewarding nuclear power's zero-carbon generation or its unrivaled reliability. More than a quarter of U.S. nuclear power plants don't make enough money to cover their operating costs, raising the threat of more early retirements.

These retirements have two important consequences concerning the used, or spent, nuclear fuel that exists on-site:

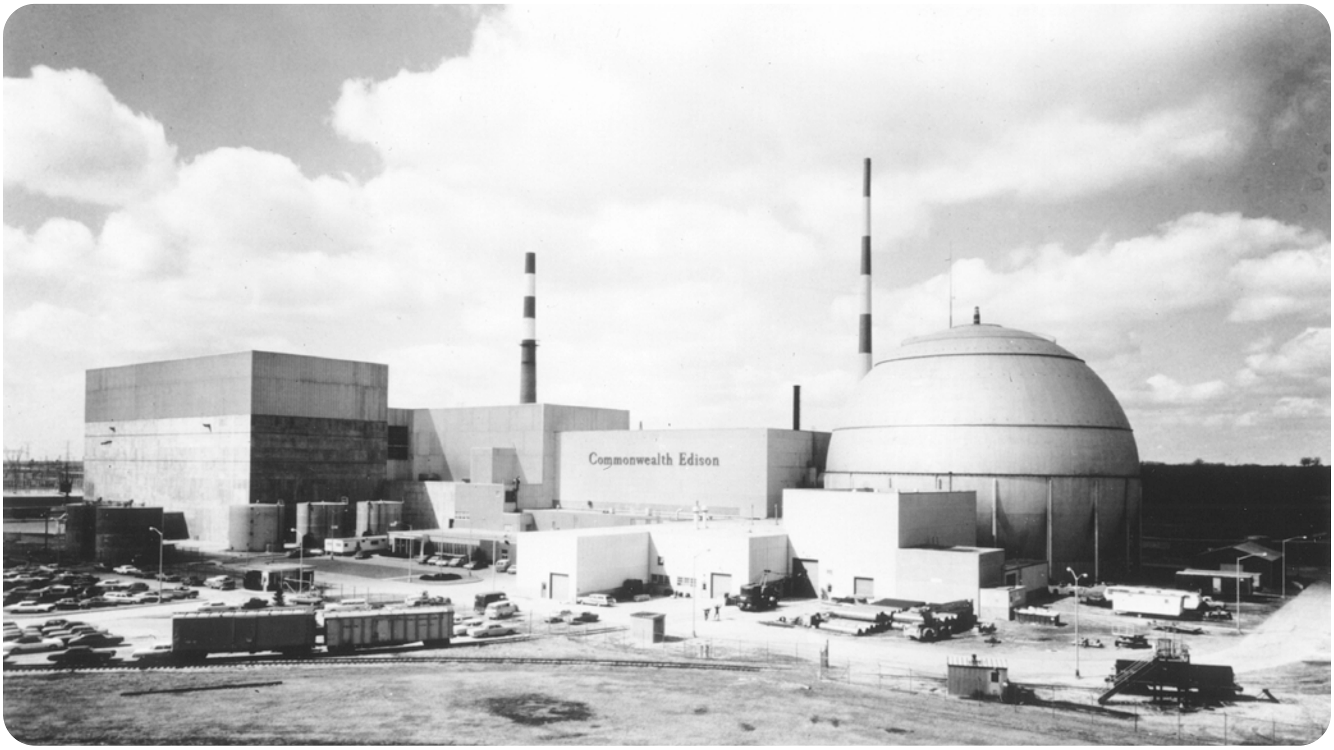
- Their spent nuclear fuel is now orphaned.
- The power plants are no longer providing power and obtaining the revenue that would continue to pay for the storage and monitoring of their spent nuclear fuel, and they are no longer paying into the Nuclear Waste Fund (NWFund), which is designed to take care of the spent fuel's ultimate disposal.

The 1982 Nuclear Waste Policy Act (NWPA) established a fee of 1 mill (one-tenth of a cent) per kilowatt-hour of electricity generated by commercial nuclear power plants and sold beginning three months after enactment of the NWPA. These fees must be paid by nuclear utilities with standard contracts and deposited in the NWFund, which is a stand-alone account in the U.S. Treasury. But in 2014, the federal government stopped collecting the NWFund fee after a successful legal battle waged by several states and the commercial nuclear industry in light of the cessation of the Yucca Mountain Project. It is unclear if fees will ever begin being collected again, although the NWFund is still accruing interest at about $2 billion/year.

The 2013 Department of Energy Fee Adequacy Assessment Report projected future revenues based on assumed nuclear energy production, no new license extensions for existing reactors, no new builds after 2012, and the fee of 1 mill/kWh produced. These assumptions may not be correct. First, as just mentioned, fee collection is on hold indefinitely. Further, most of the existing fleet has already obtained one 20-year extension, and half of the plants will most likely get another 20-year extension. The advent of small modular reactors will also change the nuclear generation picture.

However, the present wave of premature reactor closings caused by economic and political pressures in deregulated energy markets counterbalances this. Since 2012, about a dozen commercial reactors have shut down in the United States, totaling some 10,000 MW of capacity and losing over a trillion kilowatt-hours from their expected life spans, assuming one license extension for half of them and two license extensions for the other half.

Operators have announced additional planned reactor closures by 2025, though closure dates have not been set for some reactors.



An exterior view of Exelon's Dresden nuclear power station near Morris, Ill., as it appeared shortly after commissioning. It is slated for closure in 2021, a decade ahead of its current license expiration. Source: DOE

These closings represent billions of dollars lost in NWFund initial revenue from fees. On the other hand, although these fees will be lost, these prematurely closed reactors will not produce as much spent fuel. Given the high degree of maintenance being seen at almost all reactors, it is reasonable to assume for calculation purposes that all would have received another license extension, bringing their useful life spans to 80 years. If most close after only 40 years or so, then the amount of waste produced by those plants, in aggregate, will be about 50 percent of what would have been produced. If you assume a 60-year life, as in most DOE projections, then the amount of waste produced by them, in aggregate, will be about 75 percent of what would have been produced.

These are large changes and affect the final cost and schedule of any repository. But those effects are not linear, as many of the costs do not track directly with amount of waste, such as repository preparation and initial construction, waste storage at reactor sites or at consolidated interim storage facilities, modeling and monitoring, surface structures, general administrative and management costs, licensing costs, decommissioning and closure costs, and essential personnel.

It should be noted that the defense high-level waste generated by weapons production will comprise about a third of the waste disposed of in a hypothetical future centralized repository in this century—whether that's Yucca Mountain or another project. In past life cycle cost estimates for Yucca, the DOE has assumed that Congress would allocate funding through defense nuclear waste appropriations (thus from taxpayers, not ratepayers) to cover about 20 percent of the costs. This discussion will cover only the funding from the fees paid by ratepayers and collected by the commercial nuclear industry, as there are no rules or legislation controlling the DOE's defense waste disposal support.

Opinion continues

The table below shows the summary of costs for a geologic repository. The results of the 2013 fee adequacy assessment, which attempted to include inflation and economic forecasting, showed no compelling evidence that either insufficient or excess revenues were being collected to ensure the recovery of these costs by the federal government. The variation in estimates was tremendous, ranging from a negative ending balance of $2 trillion to a positive ending balance of $4.9 trillion.

Cost Estimate for Yucca Mountain*

	Historical Costs (1983–2006)	Future Costs (2007–2133)	Total Costs (1983–2133)
Repository	$ 9,910	$54,820	$64,730
Transportation	780	19,480	20,250
Other (balance of program)	2,860	8,340	11,200
Total	**13,540**	**82,640**	**96,180**

*Values in millions of dollars (2007 dollars). From the 2013 DOE Fee Adequacy Assessment Report and based on the 2008 total system life cycle cost estimate.

Folding in the premature reactor closings that could delete what I will estimate at 15 percent from the NWFund, or the probable additional license extensions that could add a similar percentage to the NWFund, does not change the conclusion that we cannot assign a meaningful probability to any of these economic forecasts. And there is no indication that these effects should bring about a change to the current fee amount.

Predicting the economic trends that control the NWFund and the cost of the Yucca Mountain Project over 100 years has little chance of providing useful information on which to base policy. Relative to the fee adequacy calculations by the DOE, the effect of premature closings may be offset by the incorrect initial assumptions of nuclear plant life spans.

The next time the DOE, or a new managing entity, prepares an updated total system life cycle cost estimate, it might be better to look at direct revenues and costs without trying to predict inflation rates or attempt economic forecasts as these direct values could be equally affected by whatever occurs. Unfortunately, the NWFund revenue is highly front-loaded over about 60 years beginning in 1983, while the construction and operation costs of the Yucca Mountain Project, or whatever replaces it, will be highly end-loaded for 60 years after 2043.

As a possible saving grace, the NWFund could accrue significant interest before any operations begin, making its financial effectiveness relatively greater. However, forecasting construction, labor, and material costs (like massive amounts of titanium) beyond mid-century gets back to being too difficult to believe, certainly for purposes of assuring congressional appropriations in the years when these expenditures would need to occur.

Projecting or estimating nuclear generation, and any fee collection, many years into the future is difficult. When and if the NWFund fee collection is restarted, it is uncertain whether any fees would be collected retroactively—although that seems unlikely.

In the end, premature plant closings will have a large, though unknown, effect on the ultimate state of our nuclear waste disposal program. The early closings might or might not be balanced by longer-than-planned life spans for those plants that stay open. Will we have more waste than expected, or less? Small modular reactors will play a role, too. Fee collection is the biggest question mark—and all of these interconnected issues will require answers sooner or later.

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, energy and the environment for Forbes, you can view his stories online, http://www.forbes.com/sites/jamesconca/.

Mark Peters, ANS member since 2007, has been named executive vice president of laboratory operations for Battelle. He will take over for Ron Townsend, who earlier this summer announced that he plans to retire in January 2021. Peters, who has served as laboratory director at Idaho National Laboratory since October 2015, will remain in this role until his successor has been selected and is in place. He will assume his new role at Battelle following this transition at INL. Prior to joining INL, Peters served as associate laboratory director of Argonne National Laboratory's Energy and Global Security directorate, which includes Argonne's programs in energy research and national security. Peters, who recently was appointed cochair of the ANS Task Force on Public Investment in Nuclear Research and Development, has also held leadership positions at Los Alamos National Laboratory and in industry. In addition, he has served two terms as chair of the National Laboratory Directors Council, representing the interests of the 17 Department of Energy national labs.


Peters

NRG Energy, part owner and operator of the South Texas Project, has announced the appointment of two new senior management members. **Jeanne-Mey Sun** was named vice president of sustainability, and **Dak Liyanearachchi** was named to the newly created position of senior vice president of data and analytics. Sun most recently worked for Baker Hughes Company, where she served as executive of energy transition and clean energy solutions. Liyanearachchi joins NRG from Hilton Worldwide, where he most recently served as chief data and analytics officer.


Sun


Liyanearachchi

The Nuclear Regulatory Commission has named **Gwynne Eatmon** the new senior resident inspector at the Beaver Valley plant in Shippingport, Pa. Eatmon joined the NRC in 2011 as a reactor inspector in the Region IV Office in Arlington, Texas. In 2014, she began serving as the resident inspector at the North Anna plant near Mineral, Va. Most recently, she was the acting senior resident inspector at the Vogtle nuclear power plant near Waynesboro, Ga.


Eatmon

Patricia L. Kampling has been elected to Xcel Energy's board of directors. Kampling has four decades of experience in the energy industry, having recently retired from her position as chairman and chief executive officer of Alliant Energy Corporation in Madison, Wis. She previously held leadership roles at Exelon Corporation and the former IPSCO Corporation.


Kampling

Arshad Mansoor has been elected chief executive officer of the Electric Power Research Institute (EPRI), effective January 1, 2021, following the retirement of current CEO Michael Howard on December 31. Mansoor will continue in his role as president, a position he has held since November 2019. Mansoor joined EPRI in 2006 as vice president for power delivery and has since held numerous leadership positions throughout EPRI. Immediately prior to his current role, he served as senior vice president of research and development, overseeing a broad-based EPRI research portfolio.


Mansoor

Obituaries

L. Walter "Walt" Deitrich, 81, ANS Fellow and member since 1970; earned a bachelor's degree in mechanical engineering from Cornell

Deitrich

University in 1961, a master's degree in mechanical engineering from Rensselaer Polytechnic Institute in 1963, and a doctorate in mechanical engineering from Stanford University in 1969; a 50-year veteran of the nuclear power industry, spent most of his career at Argonne National Laboratory, working in reactor technology and reactor safety research; served as division director of Reactor Engineering for five years; also worked at Knolls Atomic Power Laboratory in Schenectady, N.Y., and for three years (2003–2006) at the International Atomic Energy Agency in Vienna, Austria; received the University of Chicago Medal for Distinguished Performance at Argonne National Laboratory in 1999 and the IAEA Merit Award for Outstanding Performance in 2005; was part of the IAEA workforce that received the 2005 Nobel Peace Prize; died August 1.

S. Leonard Shufler, 92, ANS member since 1959; received a bachelor's degree in physics from the University of Scranton and a master's degree in nuclear physics from the University of Pittsburgh; worked at the Bettis Atomic Power Laboratory for 35 years as a nuclear physicist and manager; his major project was designing the nuclear reactor for the USS *Nimitz* aircraft carrier; served in the U.S. Navy during World War II; died February 16.

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.

Calendar

● First time listed, or significant change made.
●■ ANS event.
●■ Non-ANS event cosponsored by ANS.

October

Oct. 19–20—**20th Nuclear Security Information Exchange Meeting**, Vienna, Austria. iaea.org/events/evt1903488

Oct. 19–23—**International Conference on the Management of Naturally Occurring Radioactive Materials (NORM) in Industry**, Vienna, Austria. iaea.org/events

● Oct. 26–29—**NuMat 2020: The Nuclear Materials Conference**, Virtual meeting. elsevier.com/events/conferences/the-nuclear-materials-conference

Oct. 31–Nov. 7—**2020 IEEE Nuclear Science Symposium and Medical Imaging Conference (NSS/MIC)**, Boston, Mass. conferences.ieee.org/conferences_events/conferences/conferencedetails/42677

November

Nov. 9–13—**International Conference on Radiation Safety: Improving Radiation Protection in Practice**, Vienna, Austria. iaea.org/events/international-conference-on-radiation-safety-2020

■ Nov. 15–19—**2020 ANS Virtual Winter Meeting**, Virtual meeting. ross

Nov. 24–26—**9th International Conference on Nuclear Decommissioning (ICOND 2020)**, Aachen, Germany. icond.de/welcome.html

Nov. 30–Dec. 2—**12th Annual European Power Strategy & Systems Summit**, Prague, Czech Republic. europeanpowergeneration.eu

December

● Dec. 7–10—**OECD/NEA Specialist Workshop on Advanced Measurement Method and Instrumentation for Enhancing Severe Accident Management in an NPP Addressing Emergency, Stabilization and Long-term Recovery Phases (SAMMI-2020)**, Virtual meeting. sammi-2020.org

Dec. 8–10—**World Nuclear Exhibition (WNE 2020)**, Villepinte, France. world-nuclear-exhibition.com

January

Jan. 18–22—**15th International Congress of the International Radiation Protection Association (IRPA15)**, Seoul, South Korea. irpa2020.org

Jan. 28–29—**ICNETH 2021: 15. International Conference on Nuclear Engineering and Thermal Hydraulics**, New York City, N.Y. waset.org/nuclear-engineering-and-thermal-hydraulics-conference-in-january-2021-in-new-york

Jan. 28–30—**11th International Conference on Future Environment and Energy (ICFEE 2021)**, Tokyo, Japan. icfee.org

Jan. 28–30—**SNMMI 2021 Mid-Winter Meeting**, Society of Nuclear Medicine and Molecular Imaging, San Francisco, Calif. snmmi.org/MeetingsEvents/Content.aspx?ItemNumber=33340

February

■ Feb. 8–11—**Conference on Nuclear Training and Education: A Biennial International Forum (CONTE 2021)**, Amelia Island, Fla., ans.org/meetings/view-331

Feb. 24–26—**International Power Summit 2021**, Virtual meeting. arena-international.com/ips

March

Mar. 3–4—**Maintenance in Power Plants 2021**, Karlsruhe, Germany. vgb.org/en/instandhaltung_kraftwerken2021.html

Mar. 7–11—**WM Symposia 2021**, Phoenix, Ariz. wmsym.org

Mar. 10–11—**Enlit Australia**, Melbourne, Australia. enlit-australia.com

Mar. 16–18—**The Society for Radiological Protection Annual Conference**, Bournemouth, UK. srp-uk.org/events/2020AnnualConference

Mar. 17–19—**15th International Symposium "Conditioning of Radioactive Operational & Decommissioning Wastes" (KONTEC 2021)**, Dresden, Germany. kontec-symposium.com

Mar. 21–26—**12th International Conference on Methods and Applications of Radioanalytical Chemistry (MARC XII)**, Kailua-Kona, Hawaii. marcconference.org

Mar. 25—**Nuclear Engineering for Safety, Control and Security**, Bristol, UK. events2.theiet.org/nuclear/about.cfm

Mar. 30–Apr. 1—**PowerGen International**, Orlando, Fla. powergen.com

April

- Apr. 8-10 —**ANS Student Conference**, Raleigh, N.C. ans.org/meetings/view-student2021
- Apr. 11-15— **International Conference on Mathematics and Computational Methods Applied to Nuclear Science and Engineering (M&C 2021)**, Raleigh, N.C. mc.ans.org

Nuclear-Related Meetings Affected by COVID-19

As of September 11, 2020, the following meetings have been rescheduled, postponed, or canceled because of COVID-19 concerns.

Rescheduled

28th IAEA Fusion Energy Conference (FEC 2020)
Original date: Oct. 12–17
New date: May 10–15, 2021
iaea.org/events/fec-2020

Postponed

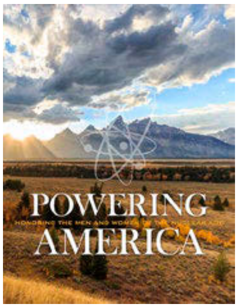
Advances in Thermal Hydraulics (ATH 2020)
Original date: Oct. 20–23
sfen-ath2020.org

Technical Meeting on Nuclear Power Plant Personnel Training
Original date: Nov. 3–6
iaea.org/events/EVT1804444

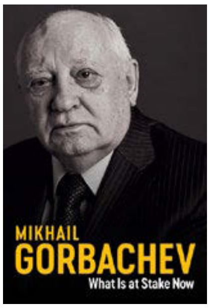
International Conference on Generation IV and Small Reactors (G4SR-2)
Original date: Nov. 9–12
g4sr.org

Publications

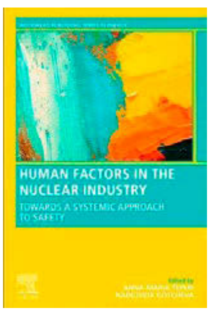
Recently Published



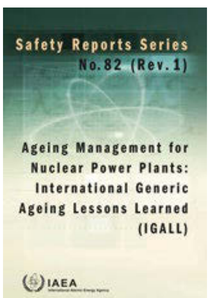
Powering America: Honoring the Men and Women of the Nuclear Age, from Remember My Service Productions. This book was created to personally thank and honor the many energy workers across America–individuals who have worked tirelessly to drive the innovations that protect, power, and improve our country. Whether researching, creating, manufacturing, managing, mining, engineering, testing, record-keeping, or performing any of the other hundreds of functions, we are indebted to their efforts. This commemorative book tells the story of America's nuclear development and innovation from the perspective of those who made, and continue to make, this industry successful. From its infancy in the Manhattan Project to the advancement of today's modern medicine and agriculture, nuclear energy has changed the way America thinks, lives, and innovates. The book pays tribute in both words and pictures to the men and women who pioneered the first 75 years of the nuclear age. (160 pp., HB, free, ISBN 978-1-7322976-6-1. Order at poweringamericabook.com.)



What Is at Stake Now: My Appeal for Peace and Freedom, by Mikhail Gorbachev and Jessica Spengler (translator). Gorbachev, the last major statesman of the 1989 revolution, wrote this book to warn us of the grave risks we now face and to urge us all, political leaders and citizens alike, to take action to address them. He focuses on the big challenges of our time, such as the renewal of the arms race and the growing risks of nuclear war, the new tension between Russia and the West, the global environmental crisis, the rise of populism, and the decline of democracy. He argues that self-serving policies and narrow-minded politics aimed at the pursuit of national interests are taking the place of political principles and are overshadowing the vision of a free and just world for all peoples. He offers his view of where Russia is heading, and he urges political leaders in the West to recognize that reestablishing trust between Russia and the West requires the courage of true leadership and a commitment to genuine dialogue and understanding on both sides. (140 pp., HB, $16.95, ISBN 978-1-509-54321-2. Order from Wiley: wiley.com.)

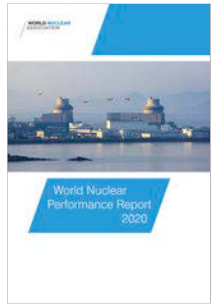


Human Factors in the Nuclear Industry: Towards a Systemic Approach to Safety, edited by Anna-Maria Teperi and Nadezhda Gotcheva. This book presents the latest research on human factors in the nuclear industry. It models and highlights scientific and technological foundations and provides practical examples of applications within a nuclear facility of human performance at an individual, group, organization, and system level. Teperi and Gotcheva supply concrete models, tools, and techniques based on research to provide the reader with knowledge of how to facilitate and support human performance in this dynamic and fast-moving safety-critical field. (350 pp., PB, $230, ISBN 978-0-08-102845-2. Order from Elsevier: Elsevier.com/books.)



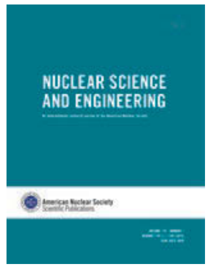
Ageing Management for Nuclear Power Plants: International Generic Ageing Lessons Learned, IAEA Safety Reports Series, No. 82 (Rev. 1). This report from the International Atomic Energy Agency provides detailed information on aging management programs and time-limited aging analyses to manage existing and potential aging effects and degradation mechanisms of structures, systems, and components that are important to the safety of nuclear power plants. It was written to assist operating organizations and regulatory bodies by specifying a technical basis and providing practical guidance on managing the aging of mechanical, electrical, and instrumentation and control components and of civil structures. It also provides a common, internationally recognized basis on what constitutes an effective aging management program, a knowledge base on aging management for the design of new plants and design reviews, and a road map to available information on aging management. (110 pp., €40 [about $47], ISBN 978-92-0-107419-5. Order from the IAEA: iaea.org/publications.)

World Nuclear Performance Report 2020, from the World Nuclear Association. In this report, the WNA details power generation and construction achievements for the previous year. In addition, the report features five case studies covering topics including reactors in France being operated in load-following mode, the operation of reactors during the COVID-19 pandemic, the commissioning of the Sanmen-1 AP1000, and the startup of the United Arab Emirates' first reactor. (68 pp., free download at world-nuclear.org.)



ANS Technical Journals

NUCLEAR SCIENCE AND ENGINEERING • OCTOBER 2020



Reduced-Order Modeling of Nuclear Reactor Kinetics Using Proper Generalized Decomposition *A. L. Alberti, T. S. Palmer*

A Multiscale Approach Simulating Generic Pool Boiling *T. Höhne, D. Lucas*

Thermal Upscattering Acceleration Schemes for Parallel Transport Sweeps *M. Hanus, J. C. Ragusa*

An Integral Experiment on Polyethylene Using Radiative Capture in Indium Foils in a High Flux D-D Neutron Generator *N. Nnamani et al.*

Model Error Estimation for the Simplified P_N Radiation Transport Equations *Y. Zhang et al.*

Mechanism of Fission Neutron Emission: New Experimental Arguments *N. V. Kornilov, S. M. Grimes*

NUCLEAR TECHNOLOGY • OCTOBER 2020

An Efficient 1-D Thermal Stratification Model for Pool-Type Sodium-Cooled Fast Reactors *C. Lu et al.*

Development of a New Method for Simulating Gas-to-Particle Conversion During Sodium Pool Fires in SFR Containment *H. Sun et al.*

Characteristic Analysis on Magnetic Field of Electromagnetic Flowmeter for Fast Reactor *X. Li*

Coupling of the Smoothed Particle Hydrodynamic Code Neutrino and the Risk Analysis Virtual Environment for Particle Spacing Optimization *E. D. Ryan, C. L. Pope*

Comprehensive Analysis and Evaluation of Fukushima Daiichi Nuclear Power Station Unit 2 *T. Yamashita et al.*

Thorium Utilization in Pressurized Water Reactors Using Bimetallic Thorium-Zirconium Alloy Cladding *S. Vaidyanathan*

Visualization of Mass Transfer Between Source and Seeping Water in a Variable Aperture Fracture—Impact of Tracer Density *H. Winberg-Wang, I. Neretnieks*

Measurement of the Gas Velocity in a Water-Air Mixture in CROCUS Using Neutron Noise Techniques *M. Hursin et al.*

Enhancement of Thermal Conductivity of Bentonite Buffer Materials with Copper Wires/Meshes for High-Level Radioactive Waste Disposal *Y. Wang, T. Hadgu*

Examining Practical Application Feasibility of Bismuth-Embedded SBA-15 for Gaseous Iodine Adsorption *S. W. Kang et al.*

New Compact Neutron Generator System for Multiple Applications *K.-N. Leung*

Transient Studies on Low-Enriched-Uranium Core of Ghana Research Reactor–1 (GHARR-1) *P. Amoah et al.*

NuclearNews *Asks*

Why are you so dedicated to education?

Eric Loewen

Eric Loewen was instrumental in setting up ANS's Navigating Nuclear program through the Discovery Education network. He is chief consulting engineer at GE Hitachi Nuclear Energy and a past president (2011–2012) of the American Nuclear Society.

Growing up in the old mining town of Leadville, Colo., the son of a door-to-door Fuller Brush salesman and a hard-working mom, I was raised with a profound sense of the importance of education. After being taught how to break the codes of math and chemistry in high school and college, I realized the importance of teachers. While serving in the U.S. Navy as a "navy nuke," I discovered my passion for nuclear science and technology and the tremendous benefits it brings to society. The confluence of those three—education, teaching, and nuclear power—has manifested in my full support of ANS's Navigating Nuclear program.

As a parent, I saw in the textbooks my children brought home that nuclear power is misrepresented. When I went into their classrooms, I saw and heard antinuclear bias. It was clear that not just the students but also the teachers held misconceptions about nuclear science and technology.

For years, ANS has conducted workshops to help give teachers the knowledge they need to teach nuclear topics with confidence. I am still part of the team that conducts the workshops. It says a lot about ANS's commitment to education that some of our most high-profile members, including past Society presidents and our current president, Mary Lou Dunzik-Gougar, have been on the A-team of our teacher professional development programs.

Our workshops are extremely popular, but we weren't reaching a wide enough audience. We needed to go much bigger to reach as many students as possible with a fact-based, scientifically vetted curriculum. We are achieving that goal with Navigating Nuclear: Energizing Our World (navigatingnuclear.com).

When I was asked to lead the Navigating Nuclear subject matter expert team, I saw the opportunity to give teachers and students something they never had—a fact-based nuclear curriculum created by the people who are doing the research and creating innovative technologies. Working with Discovery Education, a global leader in digital education, we produce engaging, accurate, easy-to-use lesson plans and project starters. We also bring nuclear science and technology to life through Virtual Field Trips that are an exciting part of the program's resources. Students get to "visit" places such as the Palo Verde Generating Station and Idaho National Laboratory.

We want students to get interested in science and to learn nuclear science objectively. At the same time, we want to show them the exciting careers available in nuclear science and technology because many students don't think there is a place for them in nuclear. Navigating Nuclear is focused on energizing our world by engaging the future of nuclear science and technology—our students.