Nuclear News

August 2021

In This Issue:

USA's ARM extends a hand in preserving nuclear competitiveness

PowerLabs, Paragon, and the Parts Quality Initiative

27th Annual Vendor/Contractor Profile Issue


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Energy
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Westinghouse eVinci™ Micro Reactor:
Power Beyond the Grid

Not every generation market is created equal – the needs of a decentralized generation market are very different than those of centralized generation. According to Navigant Research, new distributed generation power capacity is overtaking new centralized generation capacity at a growing rate.

In an effort to develop breakthrough technology to address this global market trend and aiming to serve remote consumers not connected to a national grid, Westinghouse designed the eVinci™ Micro Reactor, a next-generation small nuclear energy generator that can revolutionize how decentralized generation markets and micro-grids access clean, reliable energy.

The eVinci micro reactor aims to create competitive and resilient power with superior reliability and minimal maintenance for energy consumers in remote locations such as military outposts, far-flung communities, isolated industrial mines and critical infrastructure. Its small size allows for standard transportation methods and rapid, on-site deployment in contrast to large, centralized stations. The reactor core is designed to run for three or more years, eliminating the need for frequent refueling.

Key benefits of the eVinci micro reactor are attributed to its solid core and advanced heat pipes, which enable passive core heat extraction. This allows autonomous operation and inherent load following capabilities. These advanced technologies together make the eVinci micro reactor a pseudo “solid-state” reactor with minimal moving parts.

Other key attributes of the eVinci micro reactor include:

- Fully factory built, fueled and assembled
- Delivers combined heat and power – 1 MWe to 5 MWe
- 40-year design life
- Onsite installation estimated at fewer than 30 days
- Small site footprint with Emergency Planning Zone near zero
- Greenfield decommissioning and remediation

The eVinci micro reactor design does not rely on a safety-related instrumentation and control system, AC power or operator actions to achieve safe shutdown, which will be a step-change in nuclear innovation. Its safety is due to the design’s foundation of physics; it does not require computer signals or mechanical actuations to operate or shut down.

The eVinci design leverages the combined forces of Los Alamos National Laboratory’s (LANL) heat pipe technology and Westinghouse’s expertise in commercial reactor design, licensing and manufacturing. The resulting product will address some of today’s most challenging nuclear safety considerations, such as primary coolant loss, positive reactivity injection due to water entering the core, high-pressure eruptions and ejections, positive reactivity injection due to control rod ejection, and station blackout.

With the self-regulating core and other inherent and passive safety features, Westinghouse anticipates the eVinci micro reactor design will become one of the safest and most reliable nuclear reactor designs available. It’s part of our overarching effort to deliver affordable, reliable, flexible and sustainable energy to every type of market.

To learn more, visit
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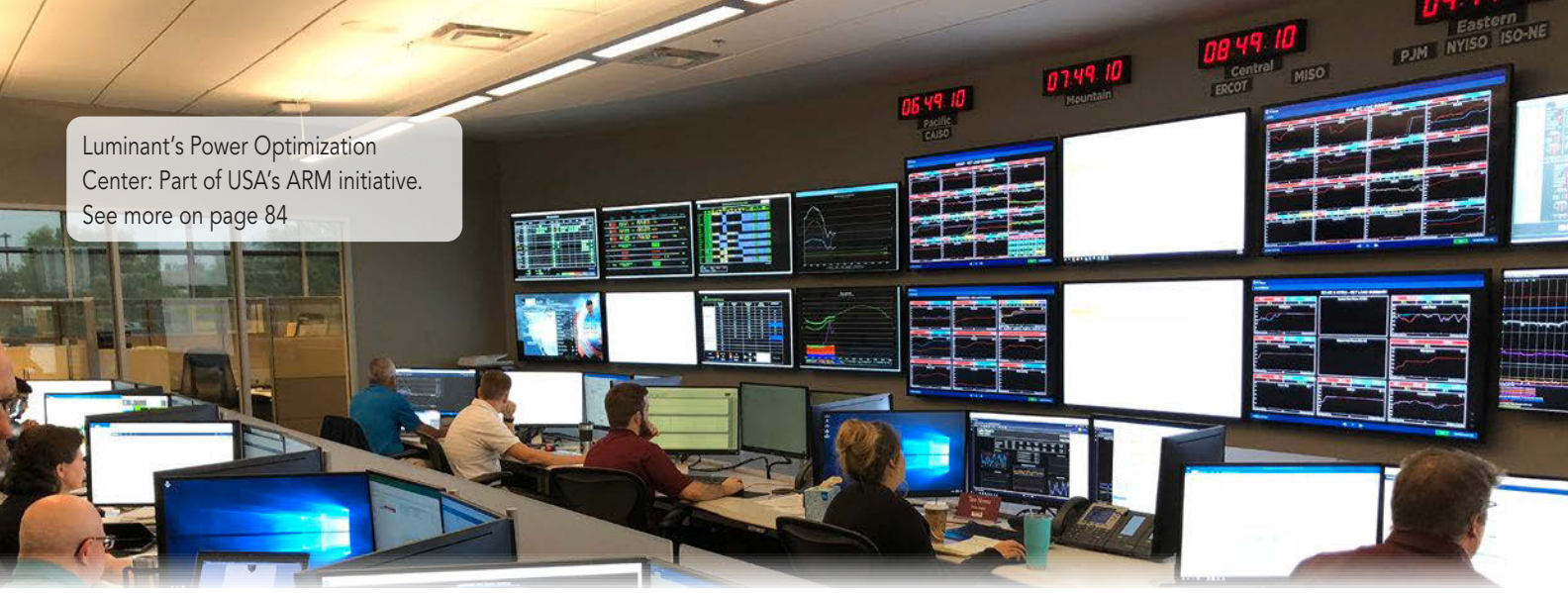

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Thank you to our advertisers

August means it's time for ANS's Utility Working Conference (being held this year at Marco Island, Fla.) and the annual *Nuclear News* "Vendor/Contractor Profile" issue. This is the 27th consecutive year that *NN* has featured the Vendor/Contractor Profile Special Section. What better time than now to discuss it with Jeff Mosses, ANS's director of advertising sales?

Mosses

Mosses (in non-pandemic times) attends more than a dozen conferences and trade shows each year to promote ANS and its publications. In talking with industry people, he is humbled to hear—"at every industry event, without exception," he said—how much they value and appreciate *NN*. A common comment, even from those who may not be ANS members or subscribers, is, "*NN* is a great magazine and resource."

NN is known for having a reach beyond the ANS membership, as editorial themes are often aligned with the topics of conferences, such as *NN*'s recent July "Health Physics/Isotopes & Radiation" issue, which was included in all attendee registration packets at the Health Physics Society's annual meeting, and the August issue (which you hold in your hands), available at the UWC and which features vendor profiles that help to keep utility decision makers informed about the newest innovations and technologies for their nuclear plants.

Mosses said that he has also heard from university people during conferences, who have told him that they use *NN* in their classrooms to help students stay current on developments in all aspects of the nuclear field.

NN's popularity means that, to some extent, it sells itself with regard to advertising. "It has the credibility of being published by the American Nuclear Society for more than 60 years, and it has its members as the core readership," Mosses said. "Plus, *NN* spans the globe, as we have readers in 58 countries, and many companies have interests or opportunities outside the United States. Vendors know they are reaching decision makers in all segments of the nuclear community."

Most companies, according to Mosses, have predetermined budgets or philosophies on print versus digital advertising. A valuable benefit for *NN* advertisers, however, is the influx of new employees in the industry and the need for knowledge transfer. ANS boasts more than 1,500 student members, with nearly half of them in graduate-level programs, and so companies that advertise are familiarizing their future employees and customers with their products and areas of expertise as the students decide on career paths.

Ad revenue is integral to helping ANS offset the production costs of *NN*. Mosses noted that vendors are not only getting a return on investment from their ads but are supporting a magazine that plays an important role in growing the nuclear community.

"*NN* has more relationships with vendors and worldwide nuclear organizations and it publishes more advertisements than all other trade publications in this space combined," he said.

To our industry partners, we say thank you. May our relationships continue for many years, to the benefit of the nuclear community. *—Rick Michal, Editor-in-Chief (rmichal@ans.org)*

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

What would the world look like without nuclear?

With the 12th Clean Energy Ministerial recently past, I thought I would reflect on the fact that the first nine CEM meetings did not include nuclear, and it wasn't until CEM10, in 2019, that it was formally part of the discussion. To me, nuclear is like the reliable student in class who consistently meets deadlines and answers questions—the student who is so dependable, in fact, that the work and effort is taken for granted. So, I wanted to investigate what the world would look like without nuclear.

To start, there would be no nuclear medicine to provide diagnostic information about the functioning of a person's specific organs, or how to treat them (every year there are more than 40 million nuclear medicine procedures performed and over 10,000 hospitals worldwide that use radioisotopes in medicine). There also wouldn't be radiotherapy to treat some medical conditions, especially cancer. Sterilization of medical equipment uses radioisotopes, and so that wouldn't be an option anymore.

The Food and Agriculture Organization of the United Nations estimates that about one in 10 people suffer from chronic undernourishment. This number would be much higher if nuclear were not used for food irradiation to increase shelf life (and kill bacteria that can cause foodborne diseases). In agriculture, a major concern is fertilizer runoff into the environment. There are fertilizers that contain radioactive "tracers" so that they can be tracked and the application of future fertilizers can be optimized. Another important nuclear application is controlling insect populations using the sterile insect technique rather than dousing the crops with herbicides.

Water is critical to life, and isotope hydrology can be used to determine a water source's history and conditions to help plan for sustainable management of the sources and optimization of irrigation. This technique is used in more than 60 countries.

Industrial tracers use short-lived isotopes to investigate processes and optimize systems, leading to efficiencies and less waste. Smoke detectors, watches and clocks, nonstick pans, and even photocopies use nuclear materials.

Radioactive materials are also crucial for nondestructive inspection (radiography) of buildings (especially after natural disasters), pipelines, concrete, and more, making the world a safer place. Without carbon dating (using radioactive carbon-14), geologists and many other scientists would be in a much tougher situation to determine the age of rocks and materials (and thus our history).

However, one of the biggest benefits nuclear provides is through power. There are about 140 nuclear-powered submarines, aircraft carriers, and ice breakers, and these can be at sea for long periods of time without refueling. Many space missions use radioisotope thermal generators to produce electricity (often in addition to solar panels). The more than 450 nuclear reactors across the world have been producing clean, reliable baseload electricity for decades, and it has been estimated that nuclear has saved over 2 million lives since 1971 by displacing fossil fuels and preventing over 64 gigatons of CO_2-equivalent greenhouse gas emissions.

I think the world has overlooked how beneficial nuclear is. With new applications such as small modular reactors (some designs can produce hydrogen, district heating, and/or desalination), next-generation baseload reactors, and fusion, we should ensure that nuclear is not overlooked for its contributions to improving the quality of life.

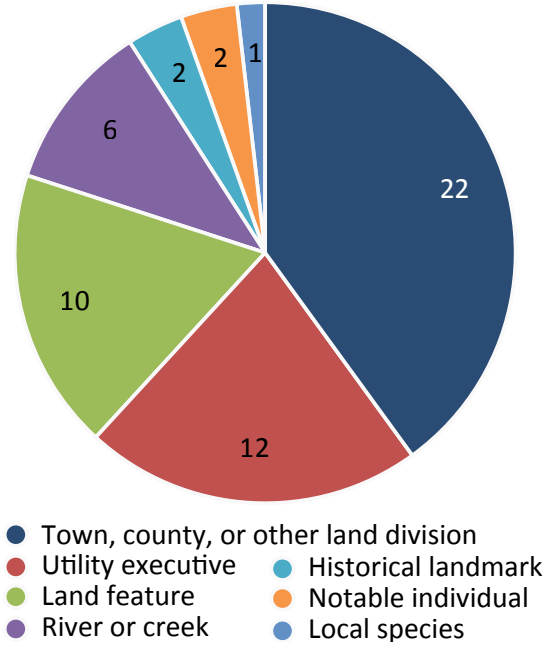
#NetZeroNeedsNuclear.

Matthew Mairinger
Bowmanville, Ontario

What's in a name?

The United States now has 93 reactors operating at 55 plant sites across the country—from Calvert Cliffs and Turkey Point in the East, to Columbia and Diablo Canyon in the West. Each has made a name for itself in the nuclear community, but the original source of each plant's name may be less well known. *Nuclear News* has conducted an informal survey of plant names and turned up a few interesting facts in the process.

U.S. Nuclear Plant Eponyms



On the map

Four plants took their names from towns or communities that formerly stood on the same land. Dresden, Ill., was a thriving canal town that became a ghost town when a railroad was laid farther to the north. It later hosted the first privately financed nuclear plant. While an unincorporated village of Peach Bottom, Pa., exists today, the original town, on the opposite side of the Susquehanna River, now hosts two boiling water reactors. The former town of Grand Gulf, Miss., was the site of a Civil War battle and is now home to the largest single reactor in the United States. Waterford was the name given to a local tract of land or community in Louisiana, farther south on the Mississippi River, where a sugar plantation was established in 1879 and a pressurized water reactor began operations in 1985.

Eighteen other plants take their names from a host or neighboring town, county, state, or other land division: Arkansas Nuclear One, Braidwood, Brunswick, Byron, Callaway, Clinton, LaSalle, Limerick, Monticello, Oconee, Perry, Prairie Island, Quad Cities, Salem, Seabrook, South Texas, St. Lucie, and Surry.

Grand Gulf, Miss., as depicted during the Civil War.

Making history

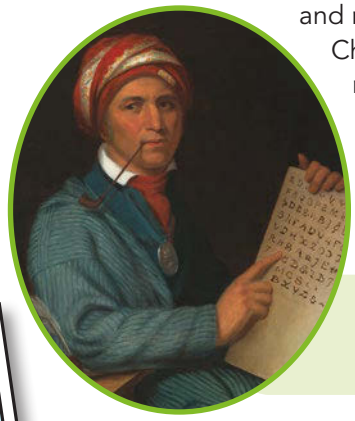
While many plant names reflect local history, only two take their names from man-made historical landmarks: Browns Ferry, built at the site of an old ferry crossing on the Tennessee River that served as a key link in the supply line for Union troops during the Civil War, and Millstone, the name and also the product of a Connecticut granite quarry that began producing stones for grist mills back in 1737.

Palo verde tree in Saguaro National Park (Rincon Mountain District), Arizona
(Photo: National Park Service)

Notable namesakes

Physicist Enrico Fermi (1901–1954), who led the development of the first man-made self-sustaining nuclear chain reaction at Chicago Pile-1, is memorialized at the Fermi plant near Detroit, Mich., where one BWR is in operation. Sequoyah (c. 1770–1843) was a scholar and member of the Cherokee Nation born near present-day Knoxville, Tenn. The plant that bears his name is located near Chattanooga, Tenn.

Enrico Fermi



Sequoyah
(Image: National Portrait Gallery)

Credit where due

Twelve operating plants were named for utility executives: Cook, Cooper, Davis-Besse, Farley, FitzPatrick, Ginna, Harris, Hatch, McGuire, Robinson, Summer, and Vogtle. Two plants can claim not one but two namesakes: Davis-Besse, which was named for John K. Davis, chairman of Toledo Edison, and Ralph M. Besse, chairman of Cleveland Electric Illuminating Company; and Cooper, which was named for a father and son, Guy Cooper Sr. and Guy Cooper Jr., who both served on the board of directors of the Nebraska Public Power District.

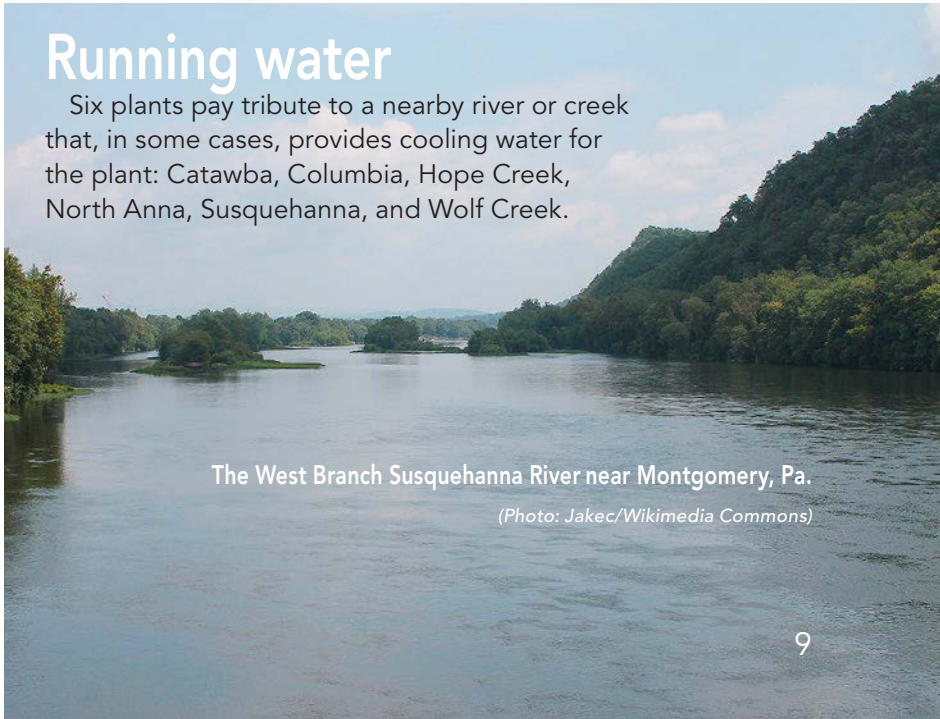
Natural features

Ten plants were named for features of the local landscape: Beaver Valley, Calvert Cliffs, Comanche Peak, Diablo Canyon, Nine Mile Point, Palisades, Point Beach, River Bend, Turkey Point, and Watts Bar.

Just one plant was named for a local species. Arizona's Palo Verde, the nation's largest nuclear plant by total capacity, is named for the state tree, a desert native. "Palo verde" translates from Spanish as "green stick" and is distinguished by its green, chlorophyll-containing trunk and branches.

Running water

Six plants pay tribute to a nearby river or creek that, in some cases, provides cooling water for the plant: Catawba, Columbia, Hope Creek, North Anna, Susquehanna, and Wolf Creek.



The West Branch Susquehanna River near Montgomery, Pa.
(Photo: Jakec/Wikimedia Commons)

The changing landscape of scholarly publishing

By John Fabian

The academic publishing industry—an industry that was very stable for over a century—is now experiencing a tremendous shift. Attitudes regarding the use, delivery, and costs of publication are at the center of the matter, causing publishers to investigate new publishing models. These changing attitudes require ANS to think differently to improve content offerings while continuing to generate needed revenue. The focus is on two trends: the elimination of author page charges, and the rise of open access publishing. The latter item is a relatively recent phenomenon that has been gaining traction over the past decade, especially in the medical and biology fields, but the former is an issue that has caused friction between authors and publishers for a generation or more.

ANS's academic publications—*Nuclear Science and Engineering*, *Nuclear Technology*, *Fusion Science and Technology*, *Transactions of the American Nuclear Society*, and individual topical meeting proceedings—are not immune to these trends. ANS needs to be aware of the changing landscape of scholarly publishing and needs to have a strategic plan on how to move forward. The shift is such that page charges are actively hurting ANS publications' reputation and pushing researchers to other venues. Meanwhile, open access is a looming threat to the century-old subscription model of revenue generation. Action is needed on these issues, but it will come at a tangible cost.

Page charges

The ANS Publications Department is a net revenue generator for the Society. That is, revenue gained from publications doesn't only cover costs—netted dollars go to support other ANS programs. The revenue from our three journals, topical proceedings, and *Transactions* can be split primarily into two categories, subscriptions and page charges. Therefore, eliminating page charges would cut into the profitability of the publications.

Yet this trend has a certain inevitable momentum. Cumulative page charge revenue for ANS publications has been slowly decreasing, year over year, because of the community's negative view of page charges and the lack of funding dollars able to be spent on publication costs.

The technical journals

In 2017, ANS entered a 10-year publishing agreement with Taylor & Francis. The agreement is entirely royalty based (a 55 percent–45 percent revenue split in ANS's favor); T&F handles all expenses and revenues, so ANS does not directly collect page charges.

T&F proposes two options for eliminating page charges from for ANS's three technical journals: all at once or a gradual decline over four years. ANS staff feels that the all-at-once option is more appealing to the community. In either scenario, complete elimination of page charges for the journals would come at a cost to ANS of $89,000 per year—a figure derived from calculating ANS's 55 percent share of the page charge revenue from 2020.

ANS and T&F staff expect that eliminating page charges would lead to greater growth for the journals, in part on reputational gains that ANS would enjoy by doing so. That expected growth would lead to other forms of revenue, a large portion of which is expected in the form of open access article publishing charges.

Transactions *and proceedings*

Beginning in 2021, *Transactions* already faces lower page charge revenue compared to previous years because of two factors: changes to the meeting program (*NN* April 2021, pp. 14–17) resulting in smaller, three-day meetings, and a 50 percent cut to page charges as part of ANS Change Plan 2020. The new expected page charge revenue for *Transactions* is about $70,000 for 2021—this is the amount ANS would seek to replace if page charges were eliminated. Replacing the lost revenue cannot follow the same model as for the technical journals, however, since content growth is limited by the size of a meeting.

Proceedings revenue is much smaller than that for the journals and *Transactions.* Currently, there is no call to change the financial model for proceedings as there is with the other publications, because page charges are built into the budget for a meeting and usually cover a minimum page count per paper. This publishing model is in line with how other not-for-profit publishers handle meeting proceedings publications.

Proceedings store sales since 2017	Copies sold	Total sales
AccApp 2017	5	$684.50
ATH 2018	5	$920.00
CONTE 2017	4	$832.50
CONTE 2019	4	$831.06
Environmental Degradation	7	$1,562.50
Global/Top Fuel 2019	11	$2,562.50
ICAPP 2018	12	$2,825.00
IHLRWM 2017	7	$1,485.00
IHLRWM 2019	6	$1,050.00
M&C 2019	4	$810.00
NCSD 2017	5	$800.62
NETS 2018	13	$2,250.00
Nonproliferation 2018	4	$831.06
NPIC&HMIT 2017	9	$2,112.50
NPIC&HMIT 2019	8	$2,035.00
NURETH 18	10	$4,575.00
PBNC 2018	3	$520.00
Plutonium Futures 2018	3	$606.06
PSA 2017	8	$1,466.00
PSA 2019	9	$1,680.00
RPSD 20	5	$938.70
Total sales	**142**	**$31,378.00**

Spotlight On continues

The bottom line is that eliminating page charges would require ANS to cover the loss of around $160,000 annually ($89,000 per the T&F proposal for journals and $70,000 estimated revenue from *Transactions*). At time of writing, ANS staff proposed some options to recover revenue in 2022 and future years, which are under consideration by the ANS Finance Committee.

Open access

Both authors and consumers benefit from open access (OA) publication. Authors that publish their research OA receive more visibility, which can lead to more citations and influence. From the consumer standpoint, supporters of OA believe it is a fiscal responsibility (for federally funded research) and a moral imperative to publish research openly to benefit underserved and underrepresented communities. Therefore, publishers are facing more pressure, year after year, to embrace OA publishing models.

While OA publishing provides benefits for both the author and consumer, it presents a challenge for the publisher. As noted in an article about OA from the Society for Scholarly Publishing, "We have rediscovered the truth that there is no such thing as a free lunch. Providing free content and services inevitably requires some form of revenue from somewhere."

The crux of the conflict lies in how the costs of publication (review systems, copyediting, typesetting, and printing, to name a few) are paid for. The historical journal publication model is based on two streams of revenue: subscription charges paid by consumers and page charges paid by content producers. Authors are no longer willing or, sometimes, able to pay page charges; meanwhile, there is a greater shift to publishing content OA, but publishers cannot charge subscribers for that freely available content.

In a fully OA model, since a publisher cannot charge for subscriptions, all of the costs of publication shift to the author instead of being split between the authors and the consumer. Therefore, in order to publish an article as OA, authors must use their funding to pay an article publishing charge (APC).

ANS staff firmly believe that adopting OA publishing now is integral to sustaining ANS publishing activities into the future. The current hybrid model for journals, giving authors the choice to publish as OA, is a good start. Eliminating page charges and adopting some further form of OA would support the wider nuclear community by removing barriers to publishing and improving accessibility of content. Taking the next step requires new funding allocations to account for a changing revenue model, but the benefits of OA publishing to authors and content users make exploration of the publishing model worthwhile.

Proceedings as a fully OA product

The ANS proceedings publications are currently offered in the form of a CD that includes PDFs of all of the papers presented at an ANS-sponsored topical meeting. Not only is this format outdated, but the series does not bring in much revenue (about $20,000 per year), with only a handful of subscribers. With relatively little revenue at risk, ANS has a unique opportunity to both update an outdated product and provide a test case for the viability of an ANS platform as an OA resource.

Such an OA platform would provide authors with more visibility and potentially more citations to their work published in the ANS proceedings. The OA content would also be indexed in databases like Scopus and Web of Science. These benefits would make ANS's proceedings a more attractive and valuable product—not just for ANS members, but also for the entire nuclear community.

To replace the lost sales and subscription revenue (as noted above, this is not a high hurdle), proceedings papers would incur an article publishing charge—but it would be low (potentially around $150 per paper). In addition, this cost either could be entirely covered by grants or sponsorships or could be split between the meeting budget and authors. This publication model could provide more value to ANS and the nuclear community, but requires a clear strategic plan and approval across different levels of ANS leadership.

Recommendations for membership to review

Action is needed on the issues of page charges and OA publishing. Eliminating page charges would create a revenue gap that ANS would have to recover, and pursuing a fully OA platform venue could extend ANS's publication portfolio, future-proof ANS against stronger calls for OA publishing options, and earn community goodwill. The final set of recommendations and options for ANS leadership to review are as follows:

- Remove page charges for journals, preferably all at once. **Cost: $89k/year**
- Three options for *Transactions* page charges:
  a. Remove page charges entirely. **Cost: $70k/year**
  b. Set page limits and move to "overlength" fee system, e.g., charge $100/page over a page limit. **Revenue: $10–20k/year [instead of the current ~$70k/year]**
  c. Allow recent changes to settle—e.g., condensed meeting structure, lower page charges—and reevaluate page charges within the next three years.
- Two options for proceedings:
  a. Keep the current "overlength" page charge fee system (in line with competitors) and eliminate CDs, moving subscriptions and store sales to an online-only product.
  b. Remove page charges for proceedings and move to a fully OA model, supported by publication plans and/or a modest APC fee to authors. **Cost: up to $20k/year in current revenue model, which could be offset with new APC/sponsorships**
- Develop use case(s) for an OA platform:
  a. Solicit input from divisions, meeting organizers, other stakeholders.
  b. Investigate funding opportunities to cover the cost to set up the platform.
  c. If option b for proceedings is pursued, the proceedings publications could become the test case for using an OA platform.

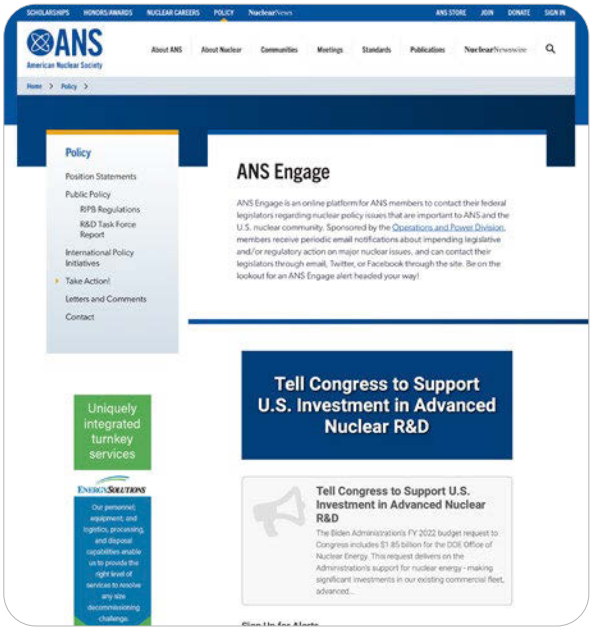
The success of OA publishing would effectively depend on whether ANS members and the nuclear community support the new model. What do you think? Should ANS embrace OA publishing? Is there a need to offer more OA publications for the nuclear community? We want to hear from you. Please email askanything@ans.org with your thoughts.

John Fabian is director of the ANS Publications Department.

ANS asks members to tell Congress to support nuclear R&D

As more than 1,500 meeting attendees were partaking in technical sessions during the 2021 ANS Virtual Annual Meeting, the American Nuclear Society launched a new policy engagement initiative aimed at drawing support for a segment of the Biden administration's fiscal year 2022 budget request. The initiative, kicked off June 15 by an email to ANS members, urged the members to send letters to their congressional representatives asking for support of advanced nuclear research and development funding.

Craig Piercy, ANS's executive director and chief executive officer, noted, "Robust public R&D investment is critical to fielding the next generation of nuclear technologies. ANS and the nuclear S&T community must raise its voice to ensure that Congress provides the funding needed to bring them to fruition."



The FY 2022 budget request includes $1.85 billion for the Department of Energy's Office of Nuclear Energy—a 23 percent increase over the FY 2021 appropriation of $1.51 billion. "President Biden's budget request puts America in the driver's seat as we transition toward a 100 percent clean energy economy," said energy secretary Jennifer Granholm on May 28. "These investments will ensure the U.S. is the global leader in research, development, and deployment of critical energy technologies to combat the climate crisis, create good-paying union jobs, and strengthen our communities in all pockets of America."

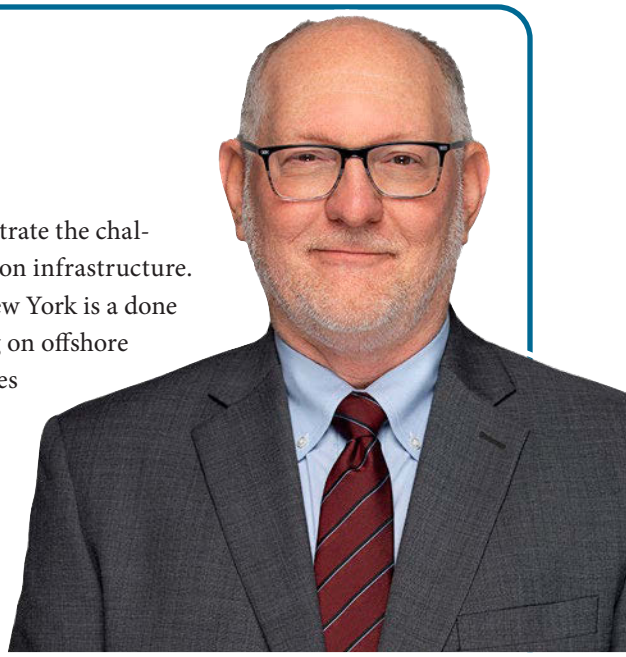
Shortly after the proposal was released, Piercy commented, "As the premier scientific and professional organization for over 10,000 nuclear engineers and technologists in the U.S., we applaud the administration's support for federal investments in advanced nuclear energy and tax credit mechanisms for our existing fleet of carbon-free nuclear power plants."

There are ways to participate in the campaign and make one's voice heard on Capitol Hill. Supporters can go directly to the ANS website (ans.org/policy/engage), search for the proper elected officials, and send letters urging action on the budget proposal. There also are options for users to spread the word on social media to help spur the nuclear community to get involved.

This campaign can only be successful with the support of ANS members and the wider community. Tell Congress to support advanced nuclear R&D now.

ANS PRESIDENT'S COLUMN

A tale of three states



Steven P. Nesbit
president@ans.org

Stories are unfolding (or have unfolded) in three of our key states that illustrate the challenges facing the backbone of our country's clean, reliable electricity generation infrastructure. I write, of course, about existing nuclear power plants. On the East Coast, New York is a done deal. Indian Point-3 shut down on April 30. The state authorities are banking on offshore wind to pick up the slack. They shrug off the cost and intermittency challenges associated with deploying wind power. We'll see.

In the middle of the country, the issue is money. Four well-performing nuclear power reactors in Illinois struggle to compete with low-priced natural gas and subsidized renewable energy in a flawed electricity market that does not adequately value the environmental and reliability attributes of nuclear power. The lack of an effective national clean energy policy handicaps efforts to address market flaws and keep the plants running. At this writing, it is not clear if proposed Illinois legislation will succeed and save the Dresden and Byron plants from planned shutdowns this fall.

On the West Coast, a decision made in the middle of the last decade threatens the environment and the energy security of California. A vocal and politically influential segment of the the Golden State's "environmental" community made a deal with the Diablo Canyon nuclear plant operator in 2016 to cease license renewal efforts and shut down its two nuclear units in 2024 and 2025. At that point, 2.2 GW of around-the-clock emission-free electricity (about 9 percent of California's power mix) will disappear, to be replaced (in theory) by 1 GW of geothermal energy and 1 GW of long-duration storage. Good luck with that.

ANS focuses on scientific and technical issues, but when it comes to nuclear power, everything goes back to economics. Our Society supports the continued operation of currently operating nuclear power plants for obvious reasons that are outlined in ANS Position Statement #26, *U.S. Commercial Nuclear Power Plants: A Vital National Asset*.

Technical professionals understand the need to look at new data and revisit old decisions when situations change. Last year, ANS submitted a letter to the Federal Energy Regulatory Commission in support of a complaint filed by a nuclear advocacy group regarding the Diablo Canyon shutdown plan. The deal to shutter the plant looks extremely unwise in 2021, coming on the heels of last year's power blackouts and the ongoing western drought that threatens grid reliability and hydroelectric power supplies.

The Indian Point experience shows that unwinding past decisions is hard. Nevertheless, it is a challenge worth tackling. ANS cannot, by itself, prevent the adverse consequences of a premature Diablo Canyon shutdown. We can, however, lend our voice and our expertise to those seeking a fact-based reconsideration of the dire situation unfolding in our most populous state.

And now for something completely different! Good news: real, face-to-face ANS meetings are back with the 2021 Utility Working Conference, August 8–11, 2021. Sign up today and I'll see you there.

Nuclear Trending continues

ANS webinar explores the future of a clean U.S. electric grid

ANS held a panel discussion on Wednesday, June 23, to look at where the United States energy system is headed in the next 15 years. The webinar, "What will a clean U.S. electric grid look like in 2035?," drew 465 viewers from 25 nations. A recording of this discussion is archived along with all past ANS webinars on the ANS webinars page (ans.org/webinars).

"While no one can say for certain exactly how the clean energy grid of the future will look, it's clear that the interactions among generators and distributors of electrons and molecules will be much more complex than they are today," said ANS President/CEO Craig Piercy, who served as moderator. "The success of nuclear will ultimately be determined in no small part by its ability to integrate into this evolving technology, economic, and policy landscape."

Ejeong Baik, a Ph.D. student in energy resources engineering at Stanford University, spoke first about the role that "clean firm resources" play in decarbonizing the power grid. Baik defined those resources as ones that are dispatchable and not necessarily dependent on weather conditions to operate. They include both renewable (biomass, geothermal) and nonrenewable (nuclear, hydrogen) resources. In a study she participated in, researchers found that "clean firm resources can reduce overall system costs, complement

ANS Webinar continues on page 18

Nuclear Notables—A history of I&R events, continued

(See NN July, page 24, for the beginning of the timeline)

1941
Glenn Seaborg discovers a new element (atomic number 94), which is called plutonium.

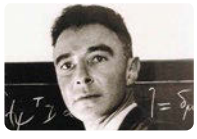
1942
Enrico Fermi and team produce the world's first controlled and sustained nuclear fission reaction at the University of Chicago.

1947
The United Kingdom builds its first atomic reactor, Calder Hall at Windscale.

1957
The UN's International Atomic Energy Agency is created to inspect nuclear reactors to ensure that they are run for peaceful purposes.

1967
The Outer Space Treaty bans nuclear weapons from being placed on any celestial body or in orbit around the earth.

1969
Preliminary SALT talks take place in Helsinki, Finland.



1942
J. Robert Oppenheimer is appointed scientific director of the Manhattan Project.

1946
President Harry S. Truman signs the Atomic Energy Act to direct the research and development of peaceful uses of nuclear energy.

1954
USS *Nautilus*, the world's first nuclear-powered submarine, is launched.

1958
Shippingport becomes the first commercial nuclear power plant in the United States.

1968
The Non-Proliferation Treaty is opened for signatures.

Bumpy roads lead to beautiful places

Craig Piercy
cpiercy@ans.org

Per *Nuclear News* tradition, this month's issue is dedicated to highlighting our nuclear technology supply chain. U.S. nuclear suppliers have certainly seen their share of challenges in the last decade or so. The widely anticipated "Nuclear Renaissance" of the early 2000s gave way to Fukushima, then a wavelet of plant closures that ANS President Steve Nesbit addresses in his column on page 17.

However, the nuclear narrative has taken on a more positive tone of late. Significant federal investments in advanced nuclear energy systems, coupled with a broader recognition of the need to decarbonize, has stoked excitement for a new generation of U.S. technology on the verge of scaled commercial deployment by the end of the decade. Hopefully, in the words of Washington Nationals manager Davey Martinez, whose team went from a 19–32 record to World Series champs in 2019, "Bumpy roads lead to beautiful places."

Clearly, there will be a few more bumps ahead. The United States is no longer the dominant supplier of nuclear technology globally. Today, the marketplace is multipolar and hypercompetitive, and as is the case with most other technology-intensive industry sectors, China is shaping up to be a formidable rival.

China is projected to have the largest nuclear fleet in the world within a decade, and it's positioning itself to aggressively market its growing technology portfolio for export, including to newcomer nations around the globe. Of course, there is also ample evidence that, along the way, Chinese nuclear companies have engaged in illegal efforts to collect sensitive U.S. nuclear intellectual property, seen most famously in the case of Allen Ho, who pleaded guilty in 2017 to "conspiracy to unlawfully engage or participate in the production or development of special nuclear material outside the U.S., without the required authorization from the U.S. Department of Energy, in violation of the Atomic Energy Act."

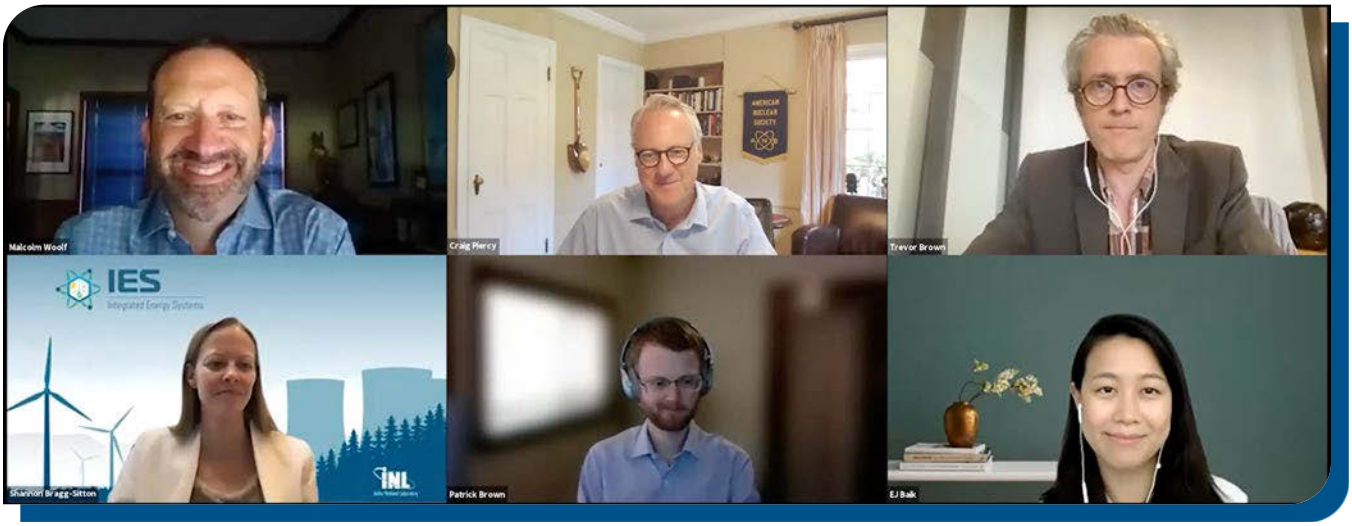
Perhaps because of this, some in Congress have called for a total cessation of bilateral nuclear cooperation between China and the U.S. Politically seductive though it may be, such a policy approach would ultimately do significant harm to America's ability to influence international nuclear safety and nonproliferation norms. Already, the 2018 U.S. Policy Framework on Civil Nuclear Cooperation with China precludes the transfer of technology related to small modular reactors, advanced reactors, and other technologies that were not already transferred before January 1, 2018. Do we really want to shut the door to all cooperation on operational safety issues, when an "accident anywhere" is still an "accident everywhere?"

Besides, even though the competition is stiffer these days, the U.S. nuclear enterprise still has a lot going for it: a strong, credible regulator in the Nuclear Regulatory Commission, world-class national laboratories and university programs, a culture of innovation within the industry, and a robust export control regime to protect those innovations from being used for nefarious purposes.

What suppliers really need is a "whole of government" approach to U.S. nuclear exports that enables more timely flow of goods and services; some DOE spending (yes, more spending) specifically targeted at building U.S. supplier capacity in critical areas, including high-assay low-enriched uranium and advanced fuels; and a strong pipeline of technically qualified people graduating from U.S. nuclear university programs and technical schools.

Perhaps most important, suppliers need a policy signal—whether it be a carbon tax, clean energy standard, nuclear production tax credit, or nuclear investment tax credit—that America is committed to decarbonizing with advanced nuclear. Such a signal would convey to investors and shareholders of U.S. suppliers that they can put their capital at risk and reasonably expect to profit from it.

The road will always be a bit bumpy for U.S. suppliers, but the stakes are too high to turn tail and go back. Here's hoping for an even thicker *NN* vendor/contractor issue next year!



Top, left to right: Malcolm Woolf, Craig Piercy, Trevor Brown. **Bottom, left to right:** Shannon Bragg-Sitton, Patrick Brown, Ejeong Baik.

ANS Webinar, continued from page 16

renewable energy resources, and enable overall operational flexibility."

Patrick Brown, a recent postdoctoral fellow at the Massachusetts Institute of Technology Energy Initiative and a current researcher at the National Renewable Energy Laboratory, presented information on his paper that examined the feasibility of decarbonizing the U.S. electricity grid using currently deployed technologies at gigawatt scale.

Shannon Bragg-Sitton, the lead for integrated energy systems in the Nuclear Science and Technology Directorate at Idaho National Laboratory, said she expects that by 2035, the United States will have first-generation advanced nuclear reactors coming on line, and that by 2050, they will be meeting even more energy demands, alongside other clean energy generators. She advocated for an "elegant solution" using multiple clean energy sources collectively to maximize their utilization.

Trevor Brown, executive director of the Ammonia Energy Association, said his group is trying to achieve two goals. The first is to decarbonize the process of making ammonia, which is the second-most-created chemical on the planet. Brown said that would eliminate roughly 1 percent of global greenhouse gas emissions. Step two would be to use those molecules in ways that focus on energy and emissions reduction. He said he is confident that the concepts of nuclear hydrogen and nuclear ammonia are going to be talked about a great deal in the near future.

Malcolm Woolf, president and chief executive officer of the National Hydropower Association, concluded the introduction portion of the discussion by asserting that the hydropower and nuclear sectors would do well to work together. "A partnership with nuclear makes a ton of sense," he said. "Neither technology is getting valued for its carbon-free attributes, and both technologies are at risk."

ANS Virtual Annual Meeting

By the numbers

The 2021 ANS Virtual Annual Meeting—hosted live via Zoom June 14–16—was again a very successful event. For this meeting, ANS introduced an Executive Panels series in addition to the technical and plenary sessions that ANS national meetings have long been known for. These panels provided a broader look at developments in nuclear science and technology and their impact on policy and markets. In addition, the 12th Nuclear Plant Instrumentation, Control and Human-Machine Interface Technologies embedded topical went live even longer, June 14–17. Check out the stats below, and read a recap of both meetings starting on page 22.

1,600 registered attendees

hailing from **28** countries

141 attendees for a single technical session
(Per Nuclear Ad Astra—The Future of Space Nuclear Technologies)

Average of **45** attendees per technical session

4 plenary sessions with live attendance peaking at over **750**

ANS Annual Meeting

70 technical sessions packed into **3** busy days

26 panel sessions

44 paper sessions

NPIC&HMIT

43 technical sessions over **4** days

11 panel sessions

32 paper sessions

63 committee and professional division meetings

212 hours of session recordings archived in the Meeting Portal for registered attendees to view

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Annual Meeting: Breaking through to deployment

The 2021 ANS Virtual Annual Meeting, the theme of which was "Breaking Through to Deployment," was held June 14–17 and drew nearly 1,600 attendees.

ANS President Mary Lou Dunzik-Gougar and ANS Executive Director and Chief Executive Officer Craig Piercy kicked off the Annual Meeting—and the opening plenary session—with a celebratory embrace of ANS successes one year after the Society produced its first fully virtual Annual Meeting.

Dunzik-Gougar reflected on the remarkable experience of serving as ANS president during a pandemic.

"While there was much opportunity and even demand for change in the past year, change is still not easy, and it's often uncomfortable," she said. "In our highly regulated nuclear science and technology community, we tend to be conservative and a bit risk averse, avoiding significant change. But sometimes risk-taking is necessary. By approving the Change Plan in 2019, our Board took a risk. Since then, our committed members and staff accepted that risk in making these plans a reality. Today, it looks like the risks were the right ones to take."

Piercy agreed. "Truly, the progress that we've made is a testament to what happens when a community, despite all its internal divisions and complexity, makes up its mind to do and be better," he said. "Our success is also buoyed by a growing awakening of the value of nuclear technology in tackling decarbonization, resiliency, and the overall sustainability of our world."

The general chair of the meeting, Thomas Zacharia, director of Oak Ridge National Laboratory, introduced Secretary of Energy Jennifer Granholm and five distinguished panelists, each with close ties to nuclear deployment and the DOE's Advanced Reactor Demonstration Program (ARDP).

"Right now, we need you," said Secretary Granholm in prerecorded remarks. "President Biden is absolutely committed to getting this country powered by clean energy using every single clean energy tool available. Let me say loud and clear, carbon-free nuclear power is an absolutely critical part of our decarbonization equation. But we're not just talking the talk here. This administration is walking

Piercy

Dunzik-Gougar

Zacharia

Granholm

the walk. And you can see that in the president's 2022 budget, and you can see it in the American Jobs Plan."

The recently released budget calls for $1.8 billion in nuclear energy funding, which Granholm described as "by far our largest proposed investment ever."

"To start with, we want to preserve our existing nuclear fleet," she said. The budget includes $175 million for fleet modernization efforts, including the development of advanced, accident-tolerant fuels. "We're going to keep doing everything we can to encourage our partners in the states to keep their reactors on line.

"At the same time, we are making it a priority to fund and find a long-term disposal solution to nuclear waste. We know it's not going to be Yucca Mountain. Instead, we want to move forward with a consent-based siting strategy. It's why our funding request includes $20 million to support near-term consolidation and storage."

Granholm said that when it comes to advanced reactors, "there is a lot to like," and the budget request includes nearly $700 million for advanced nuclear.

"If all of that excites you," Granholm continued, "just imagine what tens of billions of dollars more for research and development and demonstration and deployment would do for nuclear energy in America." The American Jobs Plan includes those R&D investments, she said, along with a clean electricity standard and an allocated production credit for electricity generation from eligible, existing nuclear power facilities.

"Those would solve the nuclear plant retirement issue in one fell swoop," Granholm said. "It's big. The administration sees these next few years as a truly can't-miss opportunity in nuclear energy."

Following Granholm's remarks, the five panelists presented their thoughts on the meeting's theme of breaking through to deployment.

"When it comes to electricity production, job creation, and decarbonization, nuclear energy is a source that can make it all work," said Maria Korsnick, president and chief executive officer of the Nuclear Energy Institute. "Together we're going to develop and deploy the next generation of nuclear technology, and we're going to make nuclear the carbon-free core of our clean energy future. Decades of work from the people here today across academia, government, and the entire nuclear supply chain have prepared nuclear energy to meet this moment."

Korsnick

Among lawmakers, nuclear energy is enjoying hard-earned bipartisan support, Korsnick said, adding, "We need to go farther. To successfully deploy the next generation of nuclear, we need everyone, from the halls of Congress to the C-suites of the world's biggest energy companies, to realize nuclear's potential.

"Nuclear by its nature offers so much energy for the use of very little resource. I just think fundamentally the business proposition that we bring makes a lot of sense," Korsnick said, adding that CEOs must be convinced that nuclear makes good business sense.

"Once it makes a good business case sense, things really fall quickly into place," Korsnick said. "It makes sense to relicense your plants. It makes sense to build more plants. But as long as there's very, very cheap natural gas and no concern if you're burning natural gas, I think that will continue to be a challenge."

Levesque

"At TerraPower, we approach the energy industry differently—more like a tech company than a traditional energy company," said Chris Levesque, TerraPower president and CEO. TerraPower is preparing to build a Natrium ARDP demonstration reactor at the site of a retiring coal plant in Wyoming that can serve both baseload and energy storage functions, integrating with high levels of renewables and enabling its customers to capitalize on peaking opportunities.

"The Natrium system is the first nuclear concept to integrate large-scale energy storage capabilities," Levesque said. "In fact, our utility partners strongly encouraged us to invest in the storage component, and we shaped the Natrium design based on that advice."

Meetings continues

Utilities are finding that the incremental additions of wind and solar are getting more and more expensive, Levesque said. "Nuclear will really be in demand in the 2030s and 2040s. That's why it's so important that we pull off these seven-year schedules for our demos. There will be a demand for many, many advanced reactors which we believe will be sold even before our demo projects are complete."

When Congress created the ARDP, Levesque said, it realized the need for an aggressive schedule. "We needed a schedule that that got these plants on line in the 2020s because, frankly, if we don't do it, we could miss the opportunity for nuclear energy to play a big role in fighting climate change if we don't get these new technologies out there and show the world that it can be done.

"What is the government getting for return for its very significant contribution to this public-private partnership?" Levesque asked rhetorically. "A big part of it is renewing U.S. leadership in nuclear energy with advanced nuclear technology. China and Russia are beating us in new-build deployments. I think the U.S. has really decided our best play in the international market is to beat those folks with advanced technology."

Sell

Clay Sell is the CEO of X-energy, the company planning to build a four-module Xe-100 high-temperature gas reactor plant at an Energy Northwest site near Richland, Wash., as an ARDP award recipient. Previously, Sell served in the DOE as deputy energy secretary from 2005 to 2008 during the George W. Bush administration.

"I spent 10 years away from this industry," Sell said, "and when I came back to it, I was amazed by the change in the political support for our industry to solve the nation's problems. The policy support for nuclear and the extent that our nation's leaders need us to deliver is greater now than ever. And I think there are three fundamental trends in support of this rapidly improving level of political support: climate change, national security, and jobs."

The production of high-assay low-enriched uranium (HALEU) to fuel both the X-energy and TerraPower demonstrations is a critical near-term need, Sell said. X-energy's goal is ensuring a near-term supply of HALEU while working on long-term supply beyond 2030.

"From a regulatory standpoint, we will put in a license application under Part 74 for a fuel facility at a location to be announced in the coming months. We will do that in the third quarter of this year and will begin the licensing process," Sell said, adding that he anticipates that X-energy will have a fuel facility constructed and on line in late 2024 or early 2025 to support the manufacture of TRISO pebbles enriched at 15.5 percent for the Xe-100 demonstration reactor.

As for the licensing process of the Xe-100 reactor itself, "We look with great anticipation to the Part 53 rules that the NRC staff is developing, but the reality of our timelines forces to use either Part 50 or 52," Sell said. "The realities of our specific timeline at Energy Northwest really lead to, most likely, a construction license application under Part 50 around the beginning of the second quarter of 2022."

Sell indicated that while X-energy is focused on deploying a demonstration plant, its sights are set on the eventual deployment of fleets of Xe-100 reactors, and the company is talking to its partners about maintaining the mobilization of a construction crew to build another four-module Xe-100 plant at the same site.

Baranwal

Rita Baranwal was energy secretary when the ARDP program was announced in 2020. She was asked by Zacharia what advanced reactor success looks like just months after moving on from the DOE to become vice president of nuclear and chief nuclear officer at the Electric Power Research Institute.

"Success still looks like deploying something within seven years," Baranwal said. "The rest of the world is really watching us, and I think we've laid the groundwork to get there."

"We need to take up that Etch A Sketch and change how we do business," she added. "We need to be quick and nimble in technology transfer. We need to continue to leverage technology that wasn't invented in this sector when it's beneficial to us. And when it comes to innovation, we

Meetings continues

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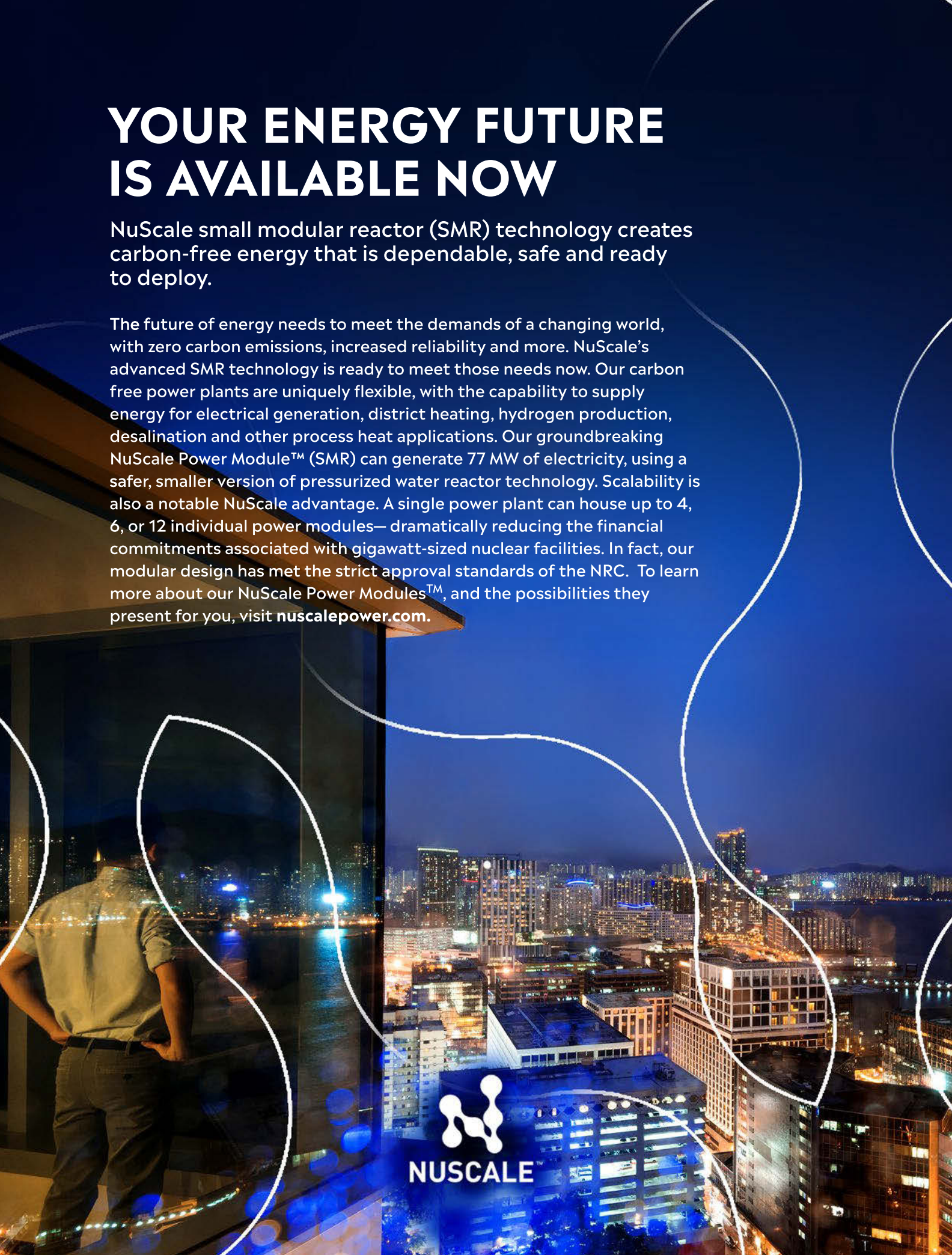


need to be failing fast, pivoting, and moving on to the next iteration of a concept to better utilize technology. That is a bit at odds with the fairly conservative nature of our industry. We've got a lot of work to do. Nuclear is stepping up to meet the challenges that are before us in the changing landscape, and it's certainly an exciting time to be in the industry."

EPRI, Baranwal explained, has an advanced reactor initiative that is a low-cost entry point to the EPRI collaborative model for the advanced reactor community. "In 2015, EPRI recognized the private sector's interest in advanced nuclear energy systems," Baranwal said. "With seed funding from EPRI's technology innovation program, a small research focus area was established with an external-facing technology advisory group within the Advanced Nuclear Technology Program. Fast forward to today. That program is now going to be pulled into our base program, and that's a success story."

Hanson

"When Congress created the ARDP, it took seriously the idea that the deployment of advanced nuclear technologies to help combat climate change faced a complex series of what I call chicken-and-egg problems," said NRC chairman Christopher Hanson, before quipping, "Well, everyone calls them chicken-and-egg problems."

"By creating a demonstration program instead of a pilot or engineering program," Hanson explained, "Congress indicated that it wanted to support relatively mature technologies that could be connected to the grid, and by virtue of that connection, those projects must be licensed by the NRC. That nexus with the NRC attempts to resolve another chicken-and-egg problem, getting the regulatory framework right to support eventual broader commercial deployment. Responding to this growing demand in a safe and secure way, consistent with the NRC's principles of good regulation—particularly clarity, reliability, and openness—is a priority for me."

Hanson spoke about the NRC's development of 10 CFR Part 53, an anticipated risk-informed licensing framework for advanced reactors. "I know we've received some criticism so far, but it's still early, and I would urge everyone to be patient," Hanson said. "The NRC must balance a number of issues to get a rule that is both comprehensive and usable for as many technologies as possible. It must be risk-informed, but where data is missing, there needs to be defense in depth. It needs to be both predictable and flexible and reconcile competing interests of vendors and utilities while considering public input. It's complex, but I'm confident we'll get there."

Hanson emphasized that the NRC would continue to work with countries embarking on new nuclear programs and share information and approaches with regulators in countries, such as Canada, that are also preparing for advanced reactor license applications.

Better TENORM regulations needed

When it comes to technologically enhanced naturally occurring radioactive materials (TENORM) produced by the oil and gas industry, "regulations have not kept up with technology," said the Environmental Protection Agency's Philip Egidi during a panel session on the opening day of the 2021 ANS Annual Meeting.

Egidi

The session, "Environmental and Radiological Impacts from Fracking," discussed the generation of TENORM wastes from the extraction of oil and natural gas by hydraulic fracturing and the industry's handling of those wastes. According to the EPA, TENORM is "naturally occurring radioactive materials that have been concentrated or exposed to the accessible environment as a result of human activities such as manufacturing, mineral extraction, or water processing."

Philip Egidi, an EPA environmental scientist and former pipeline worker, pointed out that TENORM is not federally regulated like other radioactive materials. The problem, he said, is that TENORM was not addressed by the Atomic Energy Act but was left to the states to regulate. "We need a bill, we need legislation, so that we know how to do the regulations appropriately," he said.

Panelist Elizabeth Geltman, a professor at the City University of New York's School of Public Health, agreed that reform of the oil and gas industry is needed to better manage TENORM wastes.

Geltman compared the current regulations covering the oil and gas industry to the hazardous waste regulations prior to 1980, before the Comprehensive Environmental Response, Compensation, and Liability Act, commonly known as Superfund, was established.

Geltman said there is a particular need for better post-closure oversight of fracking operations, noting that a large number of oil and gas wells in the Marcellus Shale region of the northeastern United States are close to residential areas.

While Geltman said that it cannot be definitively proven that fracking was the cause, levels of radon gas rose "exponentially" in the Marcellus region following the growth of the industry. She pointed to one study that found radon gas in the outdoor, ambient air to be 7 picocuries per liter in one area. The EPA action level for radon is 4 pCi/L.

Geltman

Science journalist Justin Nobel, the session's final speaker, called the management of facilities handling TENORM waste "atrocious," with waste being poorly managed and with little oversight from state regulators. Nobel, who investigated TENORM in the fracking industry for *Rolling Stone*, focused his talk on the lack of worker protections, noting that waste handlers are seldom told what they're working with and are given inadequate training and little or no personal protective equipment.

"I have spoken to many of these workers," Nobel said. "They do not have an understanding of what they're dealing with." Nobel claimed that employers would intentionally seek out people desperate for employment who would not question the nature of their work.

Nobel

The state of U.S. HLW management

It has been almost 40 years since the Nuclear Waste Policy Act established a program for the safe, permanent disposal of the nation's used nuclear fuel and high-level radioactive waste, yet at reactor sites across the country, used fuel and HLW continue to languish, with seemingly no solution in sight.

Increased interest in nuclear power's role in meeting growing energy needs without the use of fossil fuels, however, along with calls from the Biden administration for a new consent-based program for siting a permanent repository, offer some hope that a path exists for making real progress in addressing the back end of the nuclear fuel cycle.

Both frustration with the lack of progress on the nuclear waste issue and optimism that a solution is within reach were expressed during the panel session "Near Term Action on Nuclear Waste."

Rampal

"We are very hopeful and optimistic for action in the near term, as well as the long term, but it tends to be a bit of a mess," said Brett Rampal, of the Clean Air Taskforce. Rampal served as cochair of the session, along with Steve Nesbit, ANS vice president/president-elect and founder of LMNT Consulting.

Starting the panel discussion was Katrina McMurrian, executive director of the Nuclear Waste Strategy Coalition, a nonpartisan membership organization seeking the removal and disposal of used fuel and HLW from U.S. reactor sites. McMurrian made a point to highlight the government's inaction in taking possession of used fuel and HLW and removing it from commercial power reactor sites. She noted that as of 2020, that inaction has cost U.S. taxpayers around $8.6 billion in liability.

McMurrian

Moreover, stranded used fuel is a burden on those communities hosting a nuclear power plant, either operational or decommissioned, where used fuel and HLW are being stored. "We talk about the need for consent for a place to move spent fuel, but communities like Prairie Island [Minnesota] emphasize that they never consented to indefinite storage," she said.

McMurrian added that opportunities for action exist under the Biden administration, which has indicated its support for nuclear energy in meeting its clean energy goals, as well its support of

Meetings continues

a new consent-based siting process. McMurrian also said she was happy to hear energy secretary Jennifer Granholm acknowledge the need for a long-term disposal solution in her remarks during the opening plenary session of the Annual Meeting. "We definitely will keep reminding her of that," McMurrian said.

Davis

While noting current trends favoring nuclear development, Edward Davis, of the United States Nuclear Industry Council, posed the question, "Are we better off today than we were 40 years ago, when the Nuclear Waste Policy Act was passed?" Answering his own question, Davis said, "Marginally."

Davis, who has more than 40 years of nuclear industry experience, said he is by nature an optimistic person. "But after 40 years of effort, I think I'm entitled to a small degree of skepticism," he said.

To establish a viable path forward for dealing with used fuel and HLW, Davis recommended that the United States establish an independent nuclear waste management authority or corporation outside the purview of Congress and the Department of Energy. "I don't think we can expect to make any major progress with the status quo with regard to the way the nuclear waste program is managed today," he said.

Davis also recommended offering "significant incentives" to communities willing to host a permanent disposal facility, saying that the government already pays a lot of money to keep used fuel at reactor sites. "Pay me now or pay me later," he quipped.

McCullum

Offering the most upbeat assessment of the state of HLW management was the panel's final speaker, Rod McCullum, senior director of used fuel and decommissioning at the Nuclear Energy Institute.

McCullum said his optimism is based on the survival instinct of humans and the need to decarbonize energy production. "Decarbonization is an existential issue for the human race, and I think most human beings know that," he said. "Our desire to survive will drive us to solutions on used fuel."

As an example of the human survival instinct, McCullum shared on his screen a shot of Chicago's Wrigley Field, packed with 25,000 baseball fans. McCullum, who was at the game, said he was struck by how the people, who had just endured the pandemic, stayed in the stadium after the game had ended just to sing the home team's victory song together.

"It is testament to how strong the human survival instinct is, that when you survive something really challenging, this is what you get," he said of the joy he felt among the fans that day.

McCullum also shared reasons why he feels optimistic about finding a solution to the nuclear waste issue, including plans by General Motors to increase its production of electric vehicles; Secretary Granholm's remarks, mentioned earlier, regarding nuclear development and waste management; the pursuit of the Natrium advanced reactor project at a retired coal plant in Wyoming; and Google's pledge to make its data centers, which consume large amounts of electricity, carbon-free. "The momentum here is very strong," he said.

President's Special Session

The current orthodoxy on climate change—that it is an existential threat to global civilization—was challenged during the President's Special Session, which featured two prominent dissenters from that view, Michael Shellenberger and Mark P. Mills.

In her opening remarks, ANS President Mary Lou Dunzik-Gougar questioned the accuracy of current climate models, stating, "I have to wonder that if these models were subjected to the rigor of a Nuclear Regulatory Commission review of, let's say, a safety analysis report, that any would make the grade."

While stressing that she did not mean to "cast aspersions on climate science," Dunzik-Gougar said that she felt it is important to point out that governments are making far-reaching policy decisions likely to have significant effects on the world economy and the quality of life "based on what I suspect is far less scrutiny than is required for something like a power plant uprate application."

According to Dunzik-Gougar, the data show that having an adequate supply of energy is directly related to the quality of human life and improves the ability to withstand or recover from environmental assaults, that more than 10 percent of the world's population has no access to electricity, and that the Industrial Revolution made possible by the shift from low-energy-density biofuels to higher density fossil fuels resulted in an overall increase in human health and created a more hospitable environment.

"So, rather than a net-zero emission goal, shouldn't the ultimate goal be affordable, reliable energy to all humankind?" she asked. "Nuclear achieves this goal."

The first presenter to take the screen was Shellenberger, president of the research and policy organization Environmental Progress and author of *Apocalypse Never: Why Environmental Alarmism Hurts Us All.* He acknowledged up front that the earth is warming and that the main cause is anthropogenic. "It's mostly from fossil fuels, but also from land use changes," he added.

Shellenberger

Shellenberger also acknowledged the rise in sea levels, which is occurring about twice as fast as during preindustrial periods. "It's certainly something we'll need to adapt to, but we have a long time," he said. "It's a very slow-moving process. Anybody who's been to the Netherlands knows that humans are capable of living seven meters below sea level. The Netherlands became a wealthy country as it adapted to life below sea level. In fact, I think there's a good case to be made that it's a wealthy country because it is so technologically sophisticated that it could adapt to life below sea level. And now the Dutch are working with people in Bangladesh to make sure that they can adapt to climate change and rising sea levels."

The warming of the planet and its effect on sea levels are "not the end of the story," Shellenberger insisted. "And it's important for us to consider different facts as we consider the future before us. The first is that the United States is now the global climate leader. The United States saw the largest decline in energy-related CO_2 emissions on a per-country basis in 2019. This is a radical change from just 15 or 20 years ago, when the United States was considered the global climate villain."

Further, according to Shellenberger, the world is not seeing an increase in droughts, despite the reality of global warming. Instead, agricultural yields continue to rise, as "energy inputs, particularly fertilizer, irrigation, and the use of tractors and roads increases." Shellenberger pointed to a finding by the Food and Agriculture Organization of the United Nations that these inputs greatly outweigh any anticipated impact of climate change.

Plus, extreme poverty has declined from 44 percent to 10 percent over the past 40 years, Shellenberger said, calling the drop "one of humankind's greatest achievements." He also denied that the world is in the midst of a sixth mass extinction, noting that less than 1 percent of all species measured have gone extinct over the past 500 years. "You would need to have 75 percent or more of our species at risk of extinction, whereas just 6 percent are," he said. "And, in fact, we've done a really great job in increasing the number of protected areas around the world since 1962."

Other positives highlighted by Shellenberger include a 90 percent decline in deaths from natural disasters over the past 100 years, as well as some less-than-apocalyptic information regarding hurricanes. "We do not see an increase in economic damage from hurricanes when you account for the greater economic development," he said. "The raw increase in damage is due simply to more economic wealth, more property in harm's way. We also don't see any increase in landfalling hurricanes in the United States."

Regarding forest fires, Shellenberger bemoaned what he termed "irresponsible" and "politicized" media coverage. The main cause of high-intensity fires, he said, is bad forest management. "Climate

Meetings continues

dries the wood fuel out and extends the fire season, but the main cause of high-intensity fires is the suppression of the smaller fires, which are healthy to forests," Shellenberger said. "Suppression allows the accumulation of wood fuel." Climate change, he added, is "neither a necessary nor sufficient cause of high-intensity fires," whereas "poor forest management is both necessary and sufficient."

A strong nuclear advocate, Shellenberger also noted that "when you look at the share of electricity that nations generate from carbon-free power sources, it's those nations with a lot of nuclear that have the most carbon-free generation."

In closing, Shellenberger said that while ANS is "a very technically oriented, very engineering-oriented" organization, he hoped it would remain "cognizant of what I think is the more transcendent purpose of nuclear, which is that it's the only form of energy that can lift everybody out of poverty while reducing humankind's negative environmental impact."

Mills

Comments from Mills, a senior fellow at the Manhattan Institute, faculty fellow at Northwestern University's McCormick School of Engineering, and strategic partner at Montrose Lane, centered not on climate change but rather on the idea that the world is about to rapidly transition to new, renewable energy sources—a notion with which he takes issue.

"It's rhetorically silly, frankly—there's no other word for it," Mills said. "Every debate, every discussion, all the plans are focused not on nuclear, not on biofuels, not on switchgrass, not on ethanol, but on wind and solar and batteries. This is the monomaniacal obsession—batteries for storing grid power and for cars, of course, and wind and solar to make the electricity for the cars and for everything else. That is what is being proposed. And not just proposed. Hundreds of billions of dollars are being spent on this strategy. Hundreds of billions have already been spent, and we get a few percent of the world's energy from wind and solar so far. That's not exactly a fast transition."

On the subject of electrifying the transportation sector, Mills sees no evidence that the number of electric vehicles will increase to that forecast by the International Energy Agency—100 million on the road by 2030. And even if that number is achieved, he said, the impact on global oil demand will be minor, a decrease of only about 5 percent.

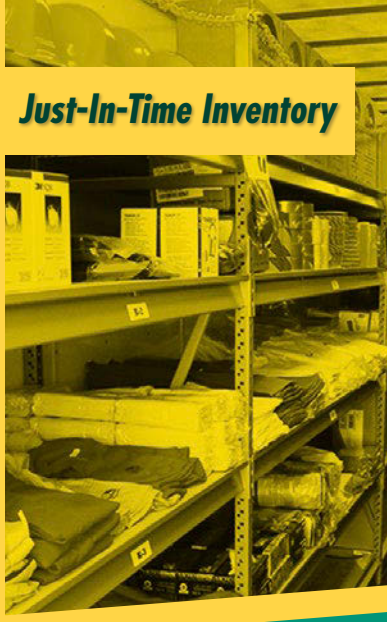
Where a rapid transition to electric vehicles would have a major impact, however, is on the global mining of minerals, according to Mills. "It is an astonishing switch in the world's energy systems in terms of the total fuel cycle to go from liquids and gases to batteries and wind and solar," he said. "The quantities of specific critical minerals required per automobile increase 300 to 600 percent when you go from a gas-powered car to an electric car. It's not just in the battery. It takes three times more copper to make an electric car than it does to make an internal combustion engine vehicle. It takes more aluminum because you have to lighten the weight of the car because of the heavy weight of the battery."

More important, Mills added, "It takes more of the critical energy minerals—things like nickel, molybdenum, lithium, cobalt, manganese, all that class of minerals. That has consequence in the mining sector. If you calculate the tons of materials that have to be mined and moved to produce batteries for the electric car world, and if you get to the year 2030 where only about 12 or 14 percent of all vehicles are electric, based on the International Energy Agency's optimistic forecast, then you're removing 50 million tons of materials per day."

Putting that number in context, Mills noted that, currently, all of the world's transportation is fueled with 5 million tons of oil per day. "This would be an astonishing, environmentally significant, economically significant increase in primary material movement," he said. "It has energy implications, environmental implications, and geopolitical implications."

Critical minerals will also be needed to construct wind and solar installations, Mills noted. "All told, if we were to meet the aspirations being proposed, world demand for these critical minerals will rise more than at any time in history," he said. "It will be the largest increase in mining demand ever

Meetings continues



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seen. It will increase demand for many of these critical minerals from 300 to 3,000 percent. None of these demands are made on the conventional energy system."

In addition, Mills said that building what he termed "the green machines" will require at least 10 times the amount of concrete, steel, and glass needed for a natural gas or nuclear plant, in order to produce the same unit of energy.

CEO roundtable

The 2021 ANS Annual Meeting brought together three leading chief executive officers from the nuclear industry for a discussion centered on the future role of nuclear energy deployment and the challenges of portfolio management during a time of net-zero carbon goals.

Participants included Jeff Guldner, CEO of Pinnacle West Capital Corporation and its subsidiary Arizona Public Service Company; Jeff Lyash, CEO of the Tennessee Valley Authority; and Jay Wileman, CEO of GE Hitachi Nuclear Energy.

Moderating the session was Thomas Zacharia, director of Oak Ridge National Laboratory and general chair of the Annual Meeting, who noted in his introductory remarks that the Biden administration's goal of net-zero carbon by 2050 presents a number of challenges, with many factors contributing to and influencing them, including regulated versus deregulated markets and regional variations in future carbon-free or carbon-neutral energy sources, as well as economic drivers. He also said that the expansion of nuclear energy has the potential to be a cornerstone of future energy strategies.

"Growth of nuclear is also likely in parallel with other carbon-free energy developments, such as the expansion of renewables, energy storage, and carbon sequestration," Zacharia said. "The economics of clean energy deployment, the maturity of nuclear technologies, and the associated risks from technology and cost will all impact strategies for the pursuit of net-zero emissions."

Zacharia also highlighted the "special role" that the national laboratories play in supporting nuclear energy and carbon-free energy deployment, pointing out that ORNL offers significant resources and expertise to industry for grid infrastructure and security, TRISO fuel development, test beds for early-stage nuclear designs, and demonstration studies for energy portfolio mixes. "Our research also holds great potential in shaping the cities of the future, including the important role nuclear can play in economic development and prosperity across our nation," he said. "Nuclear energy deployment can make an enormous positive impact on regional communities, from delivering more carbon-free energy to supporting clean energy jobs."

Guldner

Guldner reminded the audience of Pinnacle West's commitment, made in January of last year, to produce 100 percent carbon-free electricity by 2050. "We decided to go on an absolute basis," he said. "We didn't want to talk about net zero. We think it's important to send a signal to the innovation community and investors that we need to have the R&D that will actually get us to zero on the system."

The company also has interim targets of 65 percent clean energy by 2035 and a full exit from coal by 2031, according to Guldner. "Importantly, we're 50 percent carbon-free today, and that's largely because of the contribution that Palo Verde makes," he said. "We would be nowhere near that if we did not have that significant of a nuclear presence on our system."

Pathways to realizing Pinnacle West's 2035 and 2050 goals, Guldner said, include optimizing the company's existing power sources, which means, among other things, looking at the relicensing of Palo Verde in the 2040s; transportation electrification, which can help build load and help mitigate negative pricing; solving the problems of both short-term and long-term storage; and governmental assistance. "We need significant support for innovation and R&D, and I think that's a key role for the federal government to play," he said. "Another thing is the importance of flexibility in allowing us to get there. There's so much diversity in our nation's electric systems and the different

challenges we're all facing on this journey. It's really going to be tough to set a command and control, centralized policy—here's how we're going to do it and then everyone move down that path—so keep as much flexibility as possible so that we have the ability to be nimble and to adapt to local systems."

Lyash

TVA has reduced its carbon emissions against the 2005 benchmark by 63 percent as of the end of 2020, Lyash stated, attributing the accomplishment to the retirement of approximately 60 percent of the utility's coal generation; the completion of Watts Bar-2 (the only new nuclear unit commissioned so far this century); investment in the nuclear fleet with power uprates, including the nearly 500-MW uprate completed last year at Browns Ferry; and the construction of some high-efficiency gas-fired combined cycle plants.

According to Lyash, TVA has established a "strategic intent and set of guiding principles" to help it navigate the next several decades. It has committed to reducing carbon by 70 percent by 2030 and by 80 percent by 2035, he said, at which point the utility will have retired all of its remaining coal units. As for net zero by 2050, the TVA CEO described that goal as "aspirational." "We believe we can get to 80 percent by 2035 with existing technology," he said, "by continuing to leverage our nuclear and hydro fleets, adding high-efficiency natural gas as a bridge, and adding 10,000 MW of utility-scale solar, with another 2,000 MW of solar at the distribution level."

Reaching the goal of net zero, Lyash said, involves a five-point "tech agenda": (1) the electrification of the economy; (2) low-carbon fuels; (3) carbon capture; (4) long-duration storage, at a price substantially lower than today's, with characteristics that don't yet exist; and (5) new nuclear, including small modular reactors and Generation IV reactors.

"We're focused on deploying a small modular light water reactor at Clinch River," Lyash said. "We have the country's only early site permit for an SMR. We think that can have a material impact in the 2030s and help us reach that goal. And then, looking at Generation IV reactors, we're in a partnership with Kairos for its molten fluoride salt reactor, along with Oak Ridge, to look beyond the 2030s into 2040 and beyond. We think that is the pathway to net zero. Extend the existing fleet and maximize its contribution and build new nuclear if we have the right product, the right team, the right business model, and the right risk in the 2030s."

Wileman

GE Hitachi has set a goal of carbon neutrality by 2030 in all of its operations around the globe, according to Wileman. "I think that working on this energy transition is key, whether it's carbon capture or hydrogen for gas turbines, or wind and solar, or nuclear," he said. "And when I say nuclear, I mean the existing fleet, where GE Hitachi is working very hard to bring new innovations to the fleet to keep them competitive and operating through their 60- and perhaps even 80-year lives."

It is also critical, Wileman added, to look toward advanced nuclear. "At GE Hitachi, we're working on our design, the BWRX-300," he said. "To me, nuclear is a requirement to close that 80 percent to 100 percent gap to completely decarbonize electricity generation. And you have to have new nuclear in that case as well. And to be at the table, competitive, you have to have a solution that actually provides the cost targets that are workable in the industry. They've got to be able to be supported by utilities' balance sheets to move forward. So we're enthusiastic about the BWRX-300. We're targeting less than $3,000 per kilowatt-hour, about a billion-dollar project for those 300 MW, and we're continuing to work on the breakthroughs in this new nuclear space. They may be called 'small modular reactors,' but actually I see the 'S' as standing for 'simple.' It's really designing things so that you can get that cost out of there and truly be cost-competitive."

GE Hitachi is also working in the Generation IV space, Wileman noted, partnering with TerraPower to develop the Natrium sodium fast reactor, with support from the Department of Energy's Advanced Reactor Demonstration Program (ARDP). "I believe that Gen IV is the next parallel path that gets you [to net zero] in the longer term," he said.

Meetings continues

A screen shot from the CEO roundtable session: From left, Thomas Zacharia, Jeff Guldner, Jeff Lyash, and Jay Wileman.

The CEOs' opening remarks were followed by a roundtable discussion, with questions supplied by Zacharia, whose initial query was, "What do you see as the obstacles to new nuclear builds in the U.S.?"

"I think one of the important things is looking at the impact on the balance sheet, particularly for a company like mine," Guldner said. "We're a midcap electric utility, so our balance sheet is certainly more challenging than one of the big utilities to deploy new nuclear, and even at a billion dollars, you're in a little bit of a bet-the-balance-sheet on a technology. That's just a practical reality. And so I do appreciate, as we think about small modular, thinking about how to keep that cost down, how to continue to keep it effective."

Also important, Guldner noted, is stakeholder engagement. "When I started, I don't think there was much interest from a lot of the technology companies in new nuclear," he said. "Their focus was on solar, wind, and battery storage. I'm really encouraged by some of the change, as people are getting more focused on the urgency of decarbonization, and so they become more agnostic on the technology. If nuclear gets you there quicker, then we should be talking about nuclear. When you have spokespeople like Bill Gates, I think that's huge in terms of trying to buy that stakeholder perception, but it's still an issue that we have to think through—how do we build stakeholder engagement so that they're supportive of it."

"For Gen IV reactors, I think it's a technology and an engineering issue to solve," said Lyash, "so I'm going to focus my remarks on the light water small modular reactor. We need to get visibility to an *n*'th-of-a-kind competitive cost for SMRs in order to commit to a program that will produce that. And that *n*'th-of-a-kind cost has to be competitive with other energy forms in a carbon-constrained environment. We need to think about either the direct price of carbon or the social cost of carbon and have a view to a competitive *n*'th-of-a-kind product. That's important.

"The second point I would make is that we need to be very clear and transparent about the first-of-a-kind cost of developing and deploying that reactor—that there will be, there always has been, a premium for the first-of-a-kind cost. And for TVA, we cannot ask our customers to bear the first-of-a-kind premium when that's really a price to be paid to develop the product that can be used nationally

for the country to drive down carbon. And that will create a product for the United States to export around the world.

"The second element for me is addressing that first-of-a-kind cost burden. I think this is a place where partnerships can play an important role, like the one we have with Oak Ridge National Lab. But there's also a very clear role here for the federal government, in order to encourage, develop, and support this first of a kind. We see that in the ARDP pointed at Gen IV reactors that are on the horizon. I think we need a similar or companion approach to deploy light water small modular reactors that can have a material impact in the 2030s, because if we don't have that line of sight, we'll have to go in another direction because we need that impact 10 years out.

"The last thing I'd mention here that I think we have to focus on is light water SMRs," Lyash said. "I don't see the challenge as technology, licensing, fuel design—that's all based on 50 to 60 years' worth of operation. The challenge for us is deployment risk. We as an industry have not done the job we need to do at modernizing our project management, construction, supply chain, advanced manufacturing, and risk mitigation technique, to take a design and actually deploy it on schedule and on budget. And getting support and clarity around that, I think, is critical."

Meetings continues

NPIC&HMIT 2021: Digital I&C and the advanced reactor future

The pace of advances in nuclear instrumentation, control, and human-machine interface technologies—which are essential to achieving the enhanced safety and improved economics of advanced reactors—has increased in recent years.

Recent successes, lessons learned, and opportunities in implementing digital I&C in advanced nuclear reactors were discussed during the opening plenary session of the 12th Nuclear Plant Instrumentation, Control and Human-Machine Interface Technologies (NPIC&HMIT 2021) meeting, held in conjunction with the 2021 ANS Virtual Annual Meeting.

Peterson

Opening the plenary session was Per Peterson, chief nuclear officer of Kairos Power and a professor of nuclear engineering at the University of California–Berkeley, who discussed the role of university research in enabling advanced reactor technologies and the opportunities to garner lessons from other industries and technologies in modernizing nuclear I&C systems.

Peterson focused on the benefits of automation in advanced nuclear power operations, saying that a good place to look for examples of modernized automation is within the Fourth Industrial Revolution, commonly called Industry 4.0, which is automating manufacturing and industrial practices.

In particular, Peterson said that the availability of OPC Unified Architecture (OPC UA), a machine-to-machine communication protocol for industrial automation, has great potential for advanced nuclear operations. "It's interesting to think about what the implications may be for more extensive OPC UA for nuclear power I&C systems," he said.

Peterson also pointed to the autonomous systems used by SpaceX in controlling rocket launches and recoveries and Tesla's use of data collection as other examples of potential lessons that can be applied to NPIC&HMIT.

Schuppner

The session's next speaker, Suibel Schuppner, director of the Office of Nuclear Energy Technologies within the Department of Energy's Office of Nuclear Energy, provided an overview of the department's research into advanced reactor technologies.

Schuppner began by noting that there has been a surge of interest in advanced nuclear power, with a number of companies working on new reactor designs. A key benefit of all this work is that it will lead to increased U.S. economic growth and "many new jobs," she said.

"All these advanced reactors will require new advanced digital I&C technologies," Schuppner said. "There's a need to understand this new environment and an opportunity to help design the I&C infrastructure needed to support them."

Closing the plenary session was Eric Benner, director of the Division of Engineering and External Hazards in the Nuclear Regulatory Commission's Office of Nuclear Reactor Regulation, who discussed regulatory issues pertaining to digital I&C. Quoting NRC policy (SECY-19-0112), Benner said that the NRC's vision for digital I&C is to have "a clear regulatory structure with reduced

regulatory uncertainty that enables the expanded safe use of digital I&C in commercial nuclear reactors while continuing to ensure safety and security."

Among the work the NRC is doing to make the licensing of advanced reactors more efficient and predictable, Benner said, is upgrading its licensing guidance. This includes issuing a design review guide for non-light water reactor I&C, *Instrumentation and Controls for Non-Light-Water Reactor Reviews*, which he said captures lessons learned from the design review and certification of NuScale Power's small modular reactor and provides a flexible regulatory review process for non-LWRs.

Benner also noted that the NRC's interim staff guidance for digital I&C was revised to reduce uncertainty. The guidance also allows for an alternative review process, he said.

Finally, Benner said that the revised NRC Branch Technical Position 7-19 provides a risk-informed, graded approach to evaluating defense in depth in relation to common-cause failure resulting from software errors or failures.—NN *staff writers Susan Gallier, Tim Gregoire, and Michael McQueen*

Benner

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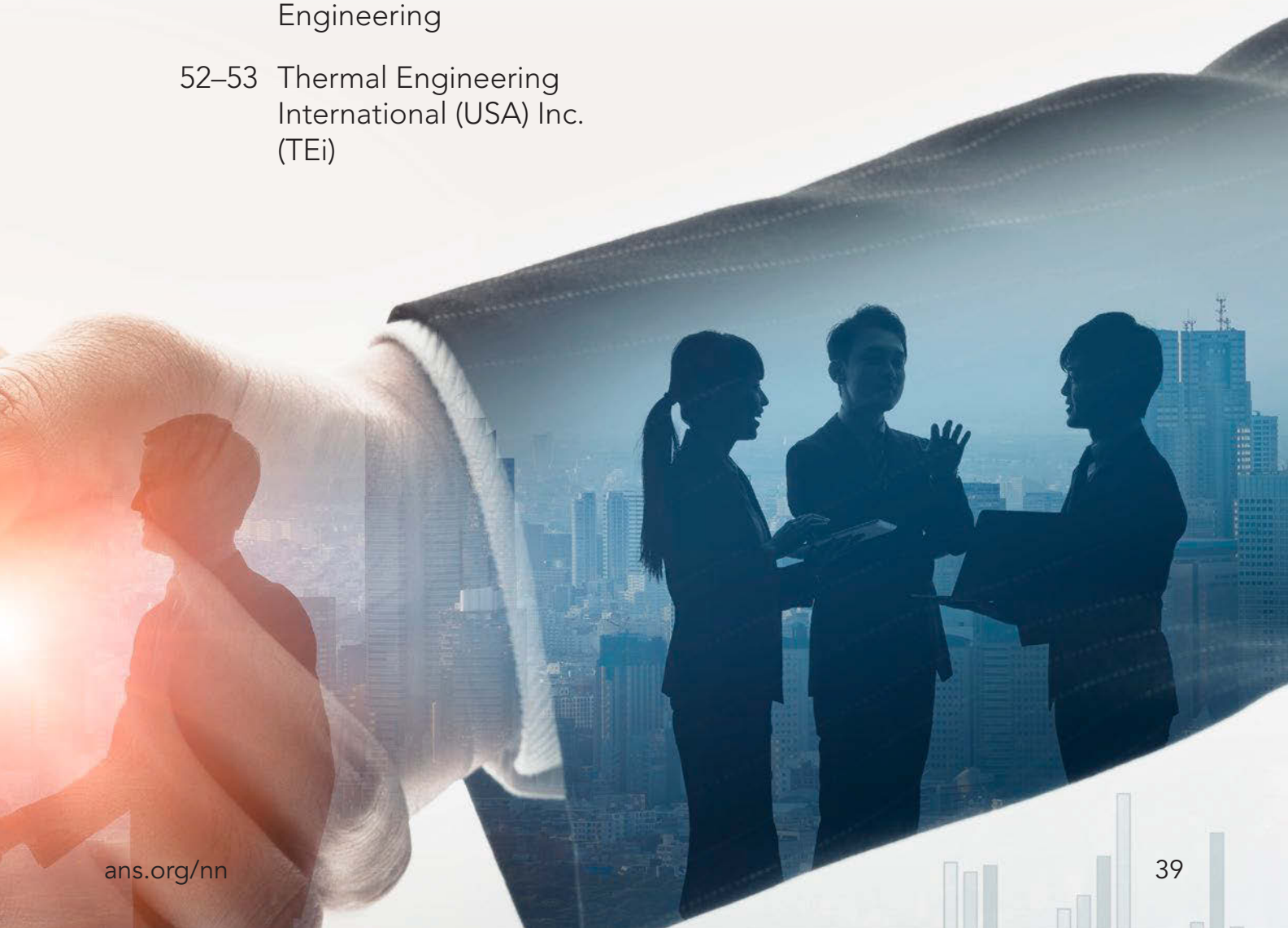

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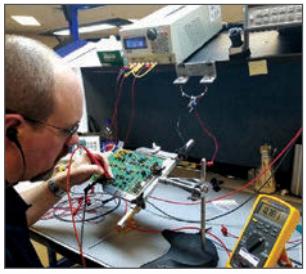

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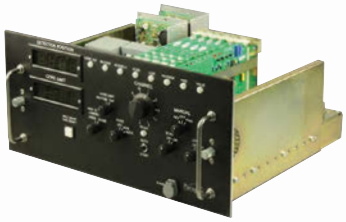

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- CID based cameras allow at least an order of magnitude improvement in operation when compared to CCD and CMOS based cameras and imagers.

Charge Injection Device

- The Charge Injection Device (CID) is a solid state imaging sensor with capabilities well beyond the limitations of today's consumer Charge Coupled Devices (CCDs). Like a CCD, the CID uses pixels to capture images, converting light into an electronic charge which is directly displayed on a monitor or captured digitally on computer.
- The superior resistance to radiation is a significant advantage for radiation tolerant imaging within facets of the nuclear power industry, medical, dental, and space based applications, and the inherent anti-blooming performance of the CID ensures accurate image detail even under extreme lighting conditions.
- The CID is uniquely positioned to serve the growing imaging market and the challenges for higher levels of accuracy in the radiation tolerant inspection market, as well as machine vision, scientific imaging.
- Thermo Scientific - CIDTEC is the leading manufacturer of CMOS imagers using the CID pixel architecture, and supply imaging solutions to OEM's as well as end-users throughout the world.

In the United States:
For customer service, call 1-800-888-8761
To fax an order, use 1-315-451-9421
Email: sales.cidtec@thermofisher.com

International:
For customer service, call [01) 315-451-9410
To fax an order, use [01) 315-451-9410
Email: sales.cidtec@thermofisher.com

Find out more at **thermofisher.com/cidtec**

ThermoFisher SCIENTIFIC

thermoscientific

Got radiation?
See what you've been missing

Imaging in radiation environments just got easier

With superior capabilities for operating in radiation environments, the MegaRAD cameras provide excellent image quality well beyond dose limitations of conventional cameras, and are well suited for radiation hardened imaging applications

MegaRAD3 produce color or monochrome video up to 3 x 10^6 rads total dose

MegaRAD10 produce color or monochrome video up to 1 x 10^7 rads total dose

KiloRAD PTZ radiation resistant camera with Pan/Tilt/Zoom

In the United States:
For customer service, call 1-800-888-8761
To fax an order, use 1-315-451-9421
Email: sales.cidtec@thermofisher.com

International:
For customer service, call [01] 315-451-9410
To fax an order, use [01] 315-451-9421
Email: sales.cidtec@thermofisher.com

Find out more at **thermofisher.com/cidtec**

ThermoFisher SCIENTIFIC

Have you been frustrated with pricing, long lead-times, and sourcing hard-to-find or obsolete OEM valve products?

Then look to Anvil Services as your total valve solutions provider.

Anvil Services: Delivering world class engineered products & services to the Nuclear Industry

Anvil Services, an integral part of ASC-Engineered Solutions' Power and Process group, specializes in providing complete project support for severe service valve repair, replacement parts and field services to nuclear power generating customers worldwide.

Anvil Services offers over 250 years of combined engineering and field service experience

Our core expertise is in the reverse engineering and precise manufacturing of mechanical components, including obsolete or out-of-stock parts. We utilize state-of-the-art technology and best practices in the reverse engineering process – replicating "like for like" replacement parts.

Our manufacturing operations utilize the latest technical capabilities and expertise:

- CNC manufacturing
- 3D scanning-CAD
- Microscopic & PTA gas welding repair
- Precision grinding & hard surfacing
- Multi disc stack cage repair
- **We can handle any valve or valve component issue**

Maintaining steam turbine valves is a constant challenge; getting fast repair can be a nightmare

Critical steam turbine valves can take a beating during the course of regular operations, and fast repair and replacement of ferrous and non-ferrous metal valve trim parts is a major challenge.

To schedule outage service or preventative maintenance, please contact your local sales representative or Anvil Services at **732-805-4000** or email at **anvilservices@asc-es.com**

www.asc-es.com

Building connections that last™

ASC Engineered Solutions

ASC™
Engineered Solutions

Providing world class quality products and services

ANVIL SERVICES
An ASC Engineered Solution

FOR CRITICAL COMPONENT REPAIRS

Severe Service & Critical Component Repairs

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

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

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

www.asc-es.com

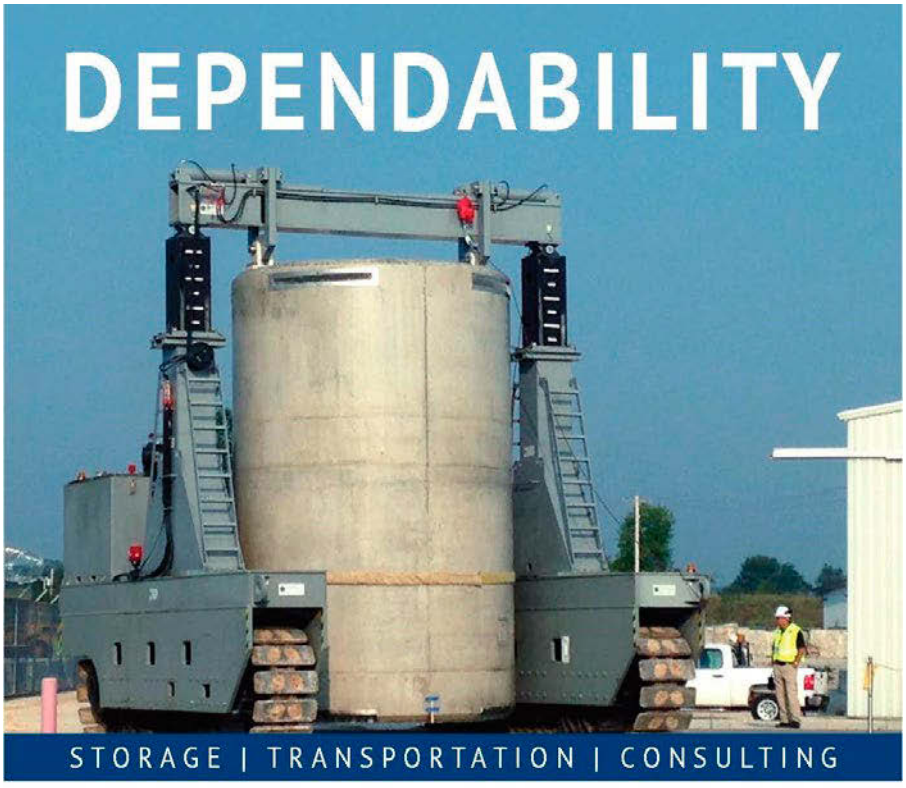
Building connections that last™

NAC International Adds New Solutions to Trusted Lineup

Already a leading solutions provider in transportation, storage, and fuel cycle consulting and information, NAC is expanding its proven, reliable offerings to increase flexibility and lower customer costs.

NAC LPT Provides Packaging Solutions for Radioactive and Hazardous Waste

NAC's new subsidiary, NAC LPT, supports decommissioning and environmental projects with a fleet of nearly 250 IP-1 intermodal containers, 10 IP-1 lidded gondola railcars, and 36 ABC railcars for material shipments. NAC LPT also provides project-specific transportation and technical services including characterization, radiological support, and expert shipping personnel.



OPTIMUS Adds Flexibility for Transportation

NAC's OPTIMUS® package is transforming nuclear material transportation and is designed to maximize flexibility to lower costs. This packaging line provides options for shielding, transport, lift, and tie down configurations for optimal flexibility and adaptability. Its variations include OPTIMUS-H to transport high-activity contents, including high fissile, remote-handled transuranic waste (RH TRU) and spent fuel, and OPTIMUS-L for low-activity contents such as contact-handled (CH) TRU, and mixed low-level waste (MLLW). We are also currently working on a larger OPTIMUS-XL design.

MAGNASTOR Storage Systems

MAGNASTOR® is a decommissioning workhorse for spent fuel storage, with flexibility to be tailored for each site's spent fuel offload needs. This system provides maximum spent fuel storage capacity and enables optimal streamlining of process durations from plant shutdown to spent fuel offload. NAC has delivered over 700 transportable spent fuel storage systems worldwide, including the industry's three leading systems, MAGNASTOR, UMS™, and MPC.

Gain Valuable Nuclear Fuel Cycle Insights and More

NAC offers insightful and up-to-date seminars, reports, and analyses on subjects important to the nuclear industry. Our internationally recognized team of industry experts combines worldwide industrial experience with global reach, detailed market analysis, and deep technical expertise.

With the NAC family of companies, we'll handle your most challenging jobs, reliability assured, every time.

NAC LPT: Logistics, Packaging, and Technical Services.

In late 2020 NAC International acquired the assets of a truck, rail, and marine logistics, packaging, and technical services company and formed NAC LPT as a wholly owned independent subsidiary of NAC International.

Through that acquisition, it allows NAC LPT to offer complete project lifecycle solutions for hazardous and radioactive waste management services.

Not only does NAC LPT have a private fleet of over 230 IP-1 Intermodal Containers, 10 IP-1 Lidded Gondola Railcars and 36 articulated bulk commodity cars, but we also provide safer, compliant, cost-effective material management services.

We have an unbiased approach to waste disposal, ensuring that our customers receive the best value for final disposition of their waste streams.

NAC LPT's staff consists of global logistics and packaging specialists, senior health physics experts, project managers, and technical personnel with radioactive materials shipping, handling, and processing backgrounds, enabling us to provide value-added services in addition to waste packaging and transportation.

We offer characterization, on-site health physics support, large component volume reduction plans, waste processing and minimization plans, material packaging solutions, transload operations, and project management support.

Combined with the expertise of NAC International and their new OPTIMUS cask systems, NAC LPT is able to provide both Type A and Type B packaging solutions and technical support in addition to our own packaging, transportation, and logistics offerings.

The NAC family of companies continues to develop our capabilities and service offerings for the industry. As a whole, our commitment to you is to provide smarter, safer, innovative solutions.

True innovation is predicated by our ability to thoroughly understand our customers' needs, and the regulations that govern the work that we all do. It also hinges upon our access to the talent and resources of the best personnel in the industry and developing earnest relationships with our partners and vendors.

It's our mission to provide complete project lifecycle solutions to our customers that sets us apart. You can count on NAC LPT to coordinate asset-based logistics, packaging, waste management, and technical services to handle your most challenging jobs.

At NAC LPT, we are here to help your projects remain compliant, mitigate risk, and keep you under budget and on schedule, reliability assured, every time.

Visit us at www.naclpt.com for more information.

NAC LPT: INTELLIGENT TURNKEY SERVICE

NAC LPT delivers smarter, safer, innovative solutions to complex projects. Count on NAC LPT's team to provide cost-saving asset-based logistics, packaging, waste management, and technical services. NAC LPT provides seamless project solutions that mitigate risk and keep you on schedule and under budget. We'll handle your most challenging jobs, every time.

NAC LPT | LOGISTICS PACKAGING TECHNICAL SERVICES

CONTACT US:
Michael Brisbin Miller, Director of Business Development
T: +1 (888) 484 4031 Ext. 106 | mmiller@naclpt.com | naclpt.com

Over 40 Years of Nuclear HVAC Experience

SSM Industries has over 40 years experience designing, qualifying, fabricating and installing HVAC ductwork and equipment in DOE facilities and Nuclear Power Plants around the world.

Our Quality Program has remained in step with the latest industry requirements and can support your NQA-1, ASME AG-1, 10CFR50 Appendix B requirements. Our fabrication personnel have been trained, qualified and maintain certifications in accordance with ASME and AWS

Let us work with you on all of your HVAC needs. From custom retrofits to new plant build, we are the HVAC solution that you have been looking for.

HVAC SYSTEM COMPONENTS

Access Doors
Actuators: Electric & Pneumatic
Air Handling Units
Charcoal Adsorber Units
Dampers:
Backdraft
Balancing
Bubble-Tight
Control: Manual, Electric & Pneumatic
Diverter
Fire & Smoke
Guillotine
HELB
Isolation
Tornado
Variable Frequency Drives
Ductwork & Supports
Fans: Axial & Centrifugal
Filters & Filtration Units (incl. HEPA)
Flexible Connections
Grilles, Registers & Diffusers
Housings
Heat Exchangers
Cooling Coils
Louvers
Plenums
Sleeves

SPECIALTY FABRICATIONS

Angle Rings
Cable Trays & Covers
Control Cabinets
Doors: Access, Heavy-Duty & Blast
Equipment Bases
Filter Boxes
Fire Barriers
U. L.-Rated, 3 Hour
Glove Boxes
Sealed Enclosures
Seismic Supports
Cooling Coils
Heating Coils
Heat Exchangers
Tanks

SSM INDUSTRIES, INC.

(412) 777-5101 • ssmi.biz

For more information please contact:
Matt Gorman mgorman@ssmi.biz
3401 Grand Avenue, Pittsburgh, PA 15225
412-901-1467 cell/text
412-777-5101 office

Nuclear HVAC fabricator

SSM Industries, Inc. entered the nuclear industry over forty years ago as the metal fabrication division of Schneider Power, based in Pittsburgh, Pennsylvania

THE POWER DIVISION OF SSM Industries Inc. provides design, qualification, fabrication, and installation support to the global nuclear market. Over $250 million of safety and non-safety related HVAC ductwork and components have been designed, tested and fabricated in our facility for use in nuclear power plants. We have supplied safety related equipment to most commercial nuclear power plants in the United States, as well as Europe and Asia.

SSM has performed complete HVAC fabrication and installation at seven nuclear power plants in the United States, and we have fabricated and supplied complete HVAC equipment scopes for nuclear power plants worldwide. These scopes include all dampers (bubbletight, tornado, manual, fire/smoke), fans (vaneaxial, centrifugal) and various components such as louvers, supports, grilles and registers.

Our nuclear qualified product line extends from the fan to the diffuser, and all HVAC products in between. In addition, we work with many plants to customize and perform commercial grade dedication activities.

One recent project for a European plant included designing, qualifying and fabricating a vaneaxial fan to replace an obsolete Reactor Containment Cooling Fan. With our experience and our partners we can find solutions for your obsolete equipment.

SSM is committed to being your source for solutions, world-class products and exceptional service. We are committed to supporting any needs you have whether big or small. We believe in integrity and customer commitment in all that we do.

SSM maintains a complete ASME NQA-1 and 10CFR50 Appendix B Quality Assurance Program. SSM is listed in the NUPIC database as a pre-qualified vendor to supply Safety Related HVAC equipment and services, including the commercial dedication of components fabricated by others, to all commercial nuclear plants. ■

SSM INDUSTRIES, INC.
POWER DIVISION

SSM INDUSTRIES, INC.
3401 Grand Avenue, Pittsburgh, PA 15255, USA
E: mgorman@ssmi.biz
W: www.ssmi.biz

Top row: **Truckload of duct for Vogtle 3 & 4**

Bottom row (from left to right): **48 inch round Safety Related Bubble Tight Damper**

Safety Related Bubble Tight Damper with undermount actuator

Safety Related Vaneaxial Fan undergoing performance testing

TEi'S JOPLIN FACILITY EXPANSION

Thermal Engineering International (TEi) a Babcock Power company is expanding its manufacturing plant in Joplin, Missouri. TEi has been a leading supplier of heat transfer technology for power generation as well as oil, gas and chemical industry applications since 1916. The existing 100,000 square foot Joplin facility is TEi's in-house fabrication plant equipped with sophisticated tooling for the manufacturing of multiple vessels associated with heat transfer equipment.

The decision to expand was in support of the renewed interest in nuclear generation and its zero emissions clean energy with the importance to "Buy American". TEi wanted the capability to offer complete MSR fabrication domestically.

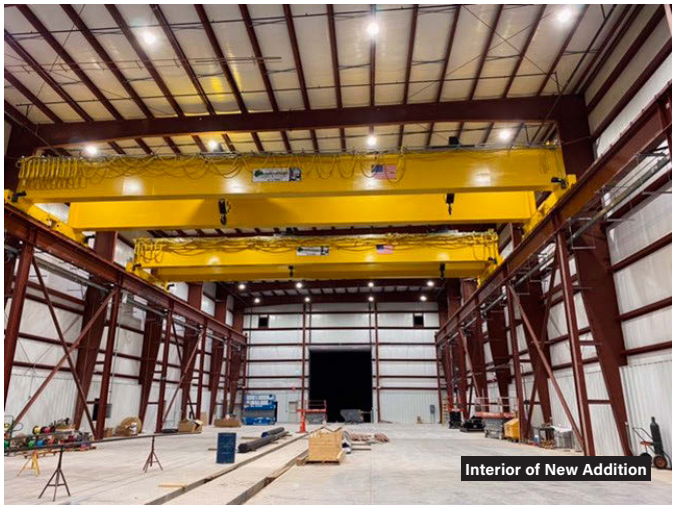
A bit of history behind TEi's MSRs: In the early 1970s, many nuclear plants worldwide experienced performance problems and frequent failures resulting from MSRs that original equipment manufacturers supplied with turbine-generators. The units must deal with very complicated and aggressive two-phase flow on both the shell side and tube side.

Aerial Shot of the Joplin Plant

Identifying the need for a reliable, high-performance MSR, TEi funded a multi-million-dollar R&D program. Among its objectives were to develop new performance-analysis routines, model testing, and advanced fabrication techniques.

The new addition provides the extra footprint required to accommodate the 'Supertanker' designs and provides TEi with a secure facility to house the expertise and quality of workmanship needed to build this equipment.

Complete MSRs Loading & Transport



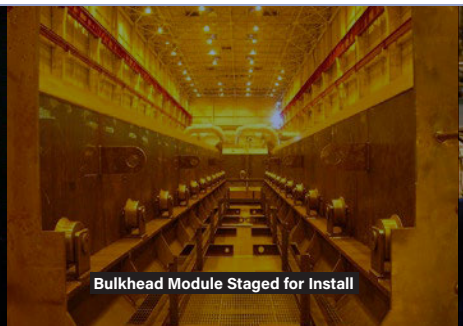
Interior of New Addition

The addition was designed with 200 ton state-of-the-art overhead cranes and and a rail spur through the middle to support loading of heavy equipment. The facility will be completed in August and start operation immediately.

MSR Supertanker Shell Fabrication

"This addition is a significant milestone in our efforts to provide a quality product to our customers. Manufacturing in the US requires a higher standard than other areas of the world and we are proud to be able to meet and exceed that demand for excellence while having served and supported America's infrastructure for over 100 years," states Ken Murakoshi, President and CEO of TEi. "We are excited that this also significantly expands our ability to be a contributing community partner by adding jobs to this growing Joplin area."

MSR Supertanker Internal Structure



Bulkhead Module Staged for Install

Reheater Bundle to Skirt Welding

TEi
a Babcock Power Inc. company

HEAT TRANSFER SOLUTIONS FROM A SINGLE SOURCE PROVIDER

A trusted supplier to the nuclear industry since 1964, THERMAL ENGINEERING INTERNATIONAL (USA) Inc. (TEi), a Babcock Power Inc. company, offers solutions that merge cutting edge technology with worldwide, world-class service.

We've supplied over 5000 units of various heat transfer equipment with over 1000 pressure vessels to nuclear power stations, including:

Over 150 MSR's In 150 Reactor Units Worldwide

Over 625 Feedwater Heaters

Over 25 Condensers & Condenser Modules

Over 200 BOP Heat Exchangers

Most Experienced Shop in the United States with Proven Compliance to Nuclear Industry Requirements

THERMAL ENGINEERING INTERNATIONAL (USA) INC.
Corporate: 18000 Studebaker Road Suite 400 | Cerritos, CA 90703
Manufacturing Facility: 2702 W 9th Street | Joplin, MO 64801
thermalengint.com | (323) 313-6783

We work to the highest standards

on projects that are anything but standard

When there is no margin for error, contact us.

N NS NPT NA CE

Air Conditioners | Chilled Fluid Units | Air Handling & Filtration Systems
Section III Heat Exchangers & Pressure Vessels | Blast & Radiation Components
IEEE Class 1E Motors | Digital and Relay-Based Analog Controls
Replacement Parts

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www.elliswatts.com

Ellis & Watts™
GLOBAL INDUSTRIES, INC.
A SUBSIDIARY OF MITEK® | A BERKSHIRE HATHAWAY COMPANY

About Us

Ellis & Watts was founded in 1952 as a designer and manufacturer of special purpose heating, ventilation, and air conditioning (HVAC) equipment. Since then, we have developed a broad capability in heat transfer, air treatment, and environmental control systems. Our equipment operates every day in hundreds of commercial fossil and nuclear power plants; industrial facilities; military facilities; and DOE/DOD project sites, in the United States, Europe, and Asia. We specialize in designing customized HVAC systems and components that meet the stringent requirements for military, medical, and nuclear industries.

Since 1952, our approach and dedication to quality, reliability, and service have remained constant. We are committed to proven problem solving techniques and traditional HVAC design methods that exceed our customer's requirements.

We have been involved with the design of next generation nuclear plant HVAC equipment for AP1000, and others.

For existing plants, we design HVAC equipment replacement solutions that match existing interfaces, space, power, and performance requirements.

Manufacturing

With over 175,000 square feet of manufacturing space under one roof, we have the ability to manufacture the HVAC equipment that we design. Our in-house capability includes: sheet metal; welding to ASME BPVC Section IX and AWS; fabrication; electrical assembly; piping; and painting. With a total lifting capacity of 40 Tons, we can fabricate large pressure vessels, and assemble chillers at our facility.

Our capability for fabricating pressure vessels includes: ASME BPVC Section VIII "U" and "UM" Stamps, and ASME BPVC Section III "N", "NPT", "NS", and "NA" Stamps.

Engineering better HVAC equipment since 1952.

Engineering

Engineering is the focal point of the Company, and our greatest strength. Our veteran engineers participate in the Codes and Standards that contribute to our industry including: ASME Boiler & Pressure Vessel Code Section III, ASME Boiler & Pressure Vessel Code Section VIII, ASME Code for Nuclear Air & Gas Treatment (AG-1), ASME Board on Nuclear Codes & Standards.

We design HVAC systems and components to the requirements of ASME Code for Nuclear Air & Gas Treatment AG-1, and qualify our equipment to the requirements of IEEE-323, IEEE-334, and IEEE-344. Our capabilities include seismic/structural analyses using Finite Element Analysis, 2D/3D CAD drawings, reliability analyses, thermal design, P&IDs, flammability analyses, radiation effects analyses, mean time between failure (MTBF) analyses, and many others.

Quality Assurance

Our ASME NQA-1 compliant quality assurance system meets nuclear industry requirements. We also meet the requirements of NUREG 0800, 10 CFR 50 Appendix B, and 10 CFR 21. For non-safety applications, we have an ISO 9001 Certified Quality System.

For pressure vessels, we have quality assurance systems meeting ASME BPVC Section III and VIII.

Testing

Our HVAC equipment is tested to ensure performance in environments that include: high ambient, low ambient, electromagnetic interference, salt spray, rain, humidity, seismic, and radiation. We have in-house testing capability for sound; power; and full/part load performance at 50Hz and 60Hz. We also perform software dedication to IEEE 7-4.3.2 and verification and validation (V&V) to the requirements to IEEE 1012 and EPRI 106439.

Ellis & Watts
Global Industries, LLC

4400 Glen Willow Lake Lane
Batavia, Ohio 45103 USA
Tel: +1-513-752-9000
Fax: +1-513-752-4545

www.elliswatts.com

Products

We engineer and fabricate custom equipment. Our past Safety and Non-Safety Related products include:

- Air Cleaning Units
- Air Conditioning Units
- Air Filtration Units
- Air Handling Units
- Chilled Water Units
- Condensing Units
- Doors for Blast, Pressure, and Radiation Shielding
- General Area Room Coolers
- Local Air Coolers
- Recirculation Fan Coil Units
- Class 1E Qualified Motors
- Dampers for Fire, Smoke, Isolation, Backdraft, and Tornado
- Electric Unit Heaters
- Fan/Motor Assemblies
- High Pressure Blowers
- Heat Exchangers
- Humidifiers / Dehumidifiers
- Louvers
- Pressure Vessels to ASME BPVC Section III and VIII

F&J SPECIALTY PRODUCTS, INC.

The Nucleus of Quality Air Monitoring Programs

Company Profile

High Volume Air Samplers

World Calibrator

Light Weight Low Volume Air Samplers

F&J endeavors to ensure its air flow measurement instruments are accurate, reliable and maximize automation for the convenience of the air sampling specialist.

F&J has a standard business strategy to implement current technology in the development of air sampling and air flow calibration instruments.

F&J implements technology driven solutions to simplify the data collection and data analysis process for the benefit of its customers.

F&J is a certified ISO 9001 and ISO 17025 air sampling instruments provider whose contributions to air sampling design ensures the air sampling specialist has the best tools to meet the ever increasing regulatory challenges in a limited manpower environment.

INTRODUCTION OF OUR PRIMARY BUSINESS

Air Flow Calibration Instruments

- High Level - World Calibrator Series - PC Interfaceable Series/User Customizable - The ultimate in end-user customization
- Mid Level - Compact Digital V.2 Series
- Level One - Mini-Calibrator Series

Common Features Include:

- Correction of Flow Rates and Volumes to a Reference T and P
- Optional correction to Ambient T and P
- Digital display of Flow, Temperature and Barometric Pressure
- Selection of Engineering units for measured and calculated parameters

TRADITIONAL AND ADVANCED TECHNOLOGY AIR SAMPLING SYSTEMS

- High Level - Global Air Sampling Systems - The ultimate in end-user customization, data management and report writing features
- Mid Level - Digital Flow Meter Systems - Automation of the air sampling process
- Level One - Analog Systems

Common Features Include:

- Rugged, Reliable and Electrically Safe
- Technology Options to match regulatory requirements
- Pricing Options to match budgets

ISO AMERICAN GLOBAL STANDARDS 17025 CERTIFIED

TUV NORD TUV USA Inc. ISO 9001

Tel: 352.680.1177 fandj@fjspecialty.com www.fjspecialty.com

F&J SPECIALTY PRODUCTS, INC.

The Nucleus of Quality Air Monitoring Programs

F&J Advanced-Technology Instruments

GAS-22
Low Volume REMP
Air Sampler System

DF-75L-400-Li

Indoor/Outdoor
Emergency Response Air Sampler
Ruggedized Enclosure

KH3-200

Tritium Collection System

FJ-46P/ FJ-40SS

Filter Holders

Filter Media

MCE Membrane Assortment, Glass Fiber,
Qualitative and Quantitative Media

RICF

Radioiodine Collection Filter Cartridges

Tel: 352.680.1177 / Fax: 352.680.1454 / fandj@fjspecialty.com / www.fjspecialty.com

Simplicity • Excellence • Enthusiasm

NUCLEAR MONITORING IS OUR FOCUS

ISEC IS THE LEADING COMPLETE SOLUTIONS PARTNER WITH A UNIQUE UNDERSTANDING OF THE NUCLEAR INDUSTRY SINCE 2003

RADCAM® AESIR

Fixed, small and lightweight with 40x zoom

RADCAM® SIGYN

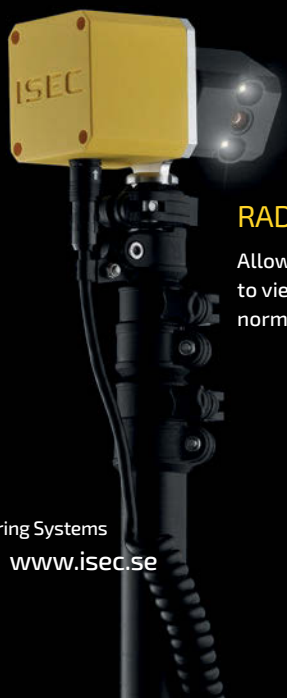
Digital Camera for fast deployment and multipurpose applications

RADCAM® EPSILON

Radiation tolerant camera for high to medium neutron and gamma radiation

RADCAM® OMEGA

Radiation tolerant camera for high to medium neutron and gamma radiation



RADCAM® LOKI

Allowing the operator to view areas which are normally out of reach

RADCAM® DELTA

ISEC's newly developed analogue camera for radiological areas

US contact:

Ron Jaworowski • Business Director Americas • ISEC Monitoring Systems

Direct: +1 704-877-8450 • Mail: ronald.jaworowski@isec.se www.isec.se

ISEC
MONITORING SYSTEMS

Perform inspections and surveys in many access challenged areas without the need of RP support, ladders, manlifts, or scaffolding.

A CASE STUDY IN REACTOR VESSEL HEAD INSPECTION WITH RADCAM® LOKI

Boric Acid 'popcorn'

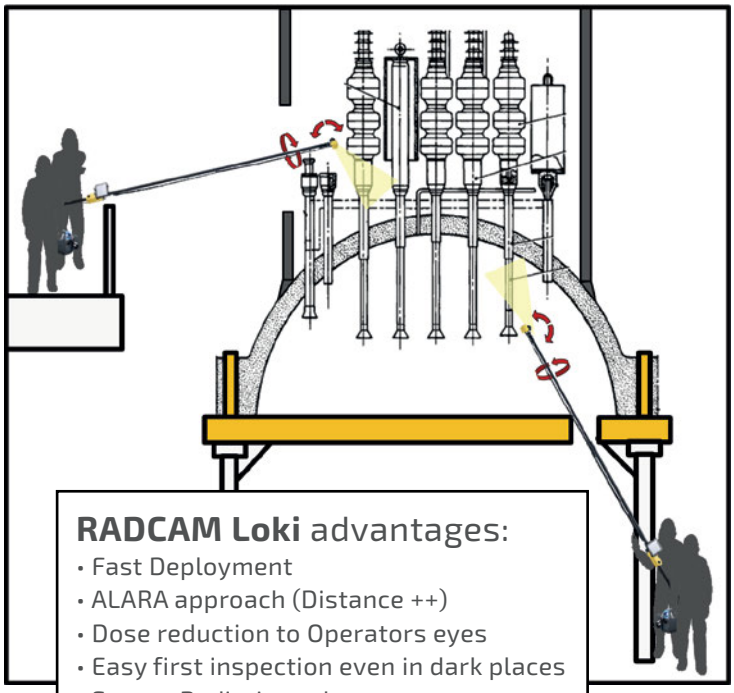
Advanced Boric Corrosion

Boric acid Corrosion of Lid

Boric acid deposits from Leak on Pen. #77

OBJECTIVE

Visual inspection of reactor vessel head penetrations to ensure no degradation due to Boric Acid corrosion.



RADCAM Loki advantages:

- Fast Deployment
- ALARA approach (Distance ++)
- Dose reduction to Operators eyes
- Easy first inspection even in dark places
- Sensor Radiation tolerance
- Instant Video / Picture collection

RADCAM Loki at the top of the RPV lid opening

RADCAM Loki inspecting the top part of the thermal Sleeves

RADCAM Loki – the camera that views areas normally out of reach.

US contact:

Ron Jaworowski • Business Director Americas • ISEC Monitoring Systems

Direct: +1 704-877-8450 • Mail: ronald.jaworowski@isec.se www.isec.se

ISEC MONITORING SYSTEMS

Attention IT

Focusing our Attention on Your Environmental Compliance

History:

Attention IT, Incorporated is a veteran-owned small business founded in 2001 to address the environmental challenges faced by federal and commercial facilities in tracking hazardous and radioactive waste. Having built a solid reputation throughout the United States, the company has grown to offer services globally from locations in the United States (U.S), Canada, and the United Kingdom (U.K).

Expertise:

We are the application developers of eMWaste® G2 Primary, specializing in hazardous, radioactive, and mixed waste tracking and management from the time of inception until disposal. The application is designed to handle all the tracking and management duties needed to safely and securely process all types of waste while cutting costs. Using a barcode scanner and computer tracking system, data is entered a single time, then securely transmitted electronically to a disposal or storage facility; all while greatly reducing data entry costs and susceptibility to errors caused by duplication of data entry tasks.

eMWaste® G2 Primary records the waste characteristics utilizing the Master Profile, the Waste Item, or the Container. Processes that reduce the waste stream in the Waste Item or Container are recorded within the application, including overpack statistics. Inventory tracks the Waste Item or Container wherever it is stored, shipped, or disposed. The Shipping papers used to deliver the waste to a disposition site (NRC Form 540, 541, EPA UHWM) are automatically populated as the Waste Item or Container is characterized.

eMWaste® G2 Primary offers an abundance of prepopulated reports or the option to create, save, and share Adhoc reports. With a “mouse click, all mandated documentation from shipping reports to barcode labels are printed directly from eMWaste® G2 Primary.

Entries selected from the Reference Tables drop-down menu is narrowed by the Waste Stream, providing consistency, and reducing data entry errors. Our Compliance Report checks every calculation within the application and prompts the user to correct any errors or oversights.

Our Customers:

eMWaste® G2 Primary is customized to the end user, is light enough to be used by individual waste shippers and brokers, yet robust enough to keep track of multiple projects and waste streams at a single sight. Clients include Decommissioning and Disposal Facilities, Power Plants, Federal Government and Commercial Sites, Landfills, and Repositories.

Our People:

Attention IT, Inc.’s staff has more than 25 years of experience in the nuclear industry. We stay abreast of technology and are well versed in the needs and expectations of our clients and potential users within the industry. Our experience allows us to adapt eMWaste® G2 Primary for use in any environment and to interface with other systems.

Qualifications/Compliance:

Attention IT, Incorporated’s Quality Assessment Manual (QAM) follows all guidelines and requirements of the NQA-1, 2008 criteria for the U.S. and U.K. and the Canadian CSA N287.7-16 Standards. Attention IT, Incorporated’s procedures and workflows has been through extensive assessments and have been approved and accepted by our clients to be compliant with the NQA-1, 2008 and CSA N287.7-16 Standards.

Please let us know if we can provide your company with any of the services we provide. We can be reached by phone at 865-769-8888 x400 or by email at jeanice@attentionit.com.

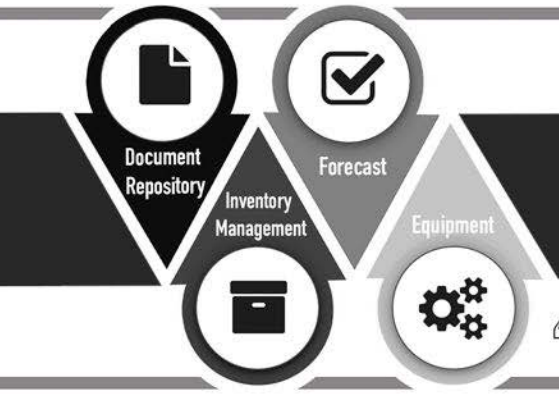
Attention IT

Focusing our Attention on your Environmental Compliance

eMWaste® G2 Primary

Attention IT

- eMWaste® G2 Primary Suites is an intuitive, interactive, and intelligent COTS software that produces the results needed by **Laboratories, Generators, Processors, Disposition Sites, and Brokers.**
- **Our software offers Barcode/RFID scanning** and tracking, extensive **Compliance Reporting** and Validation, **transmitting of electronic files, Decay calculations,** and more.



eMWaste® G2 Primary

NEW MODULES
NEW FEATURES

"Focusing our *Attention* on your environmental compliance"

GET TO KNOW US : Attention IT has over **25 years of knowledge** stored in one database and has a proven track record in the **US, UK, and Canada.** We focus on your **environmental issues** to **ensure compliance** when building waste and material records.

Environmental Qualification and Training

GLSEQ world class experience in Environmental Qualification introduces new on-line EQ training.

EQ The Beginning 50th Anniversary of IEEE 323

Earthquake Magnitude Scale and Seismic Qualification

NRC Regulatory Guide 1.100 Rev 4, Seismic Qualification

10 CFR 50.44 Combustible Gas Control

Non-Safety Severe Accident Information Systems

Strengthens capabilities for assessing risks from Beyond-Design-Basis Events (BDBA).

Improves hydrogen sensing range to 100% to overcome over range.

Costs less to install than annual maintenance on legacy hydrogen Combustible Gas systems.

Follows BWR Owners Group recommendation to increase reliability with commercial grade Combustible Gas systems.

Always on feature enhances ability to detect when DBA becomes BDBA and EOP needs to go to SAMG, necessary since time between Loss of Coolant and BDBA was 2, 4, 6, and 8 hours at TMI, Fukushima Units 1, 2 and 3, respectively.

Provides unambiguous evidence of fuel damage, reactor breach, and MCCI.

Adds enhanced monitoring of reactor building and FLEX options.

Improves accuracy to 0.6% and response time to changes to less than 60 seconds.

Follows National Research Council recommended improvements for BDBA.

Contact: Jim Gleason 256-369-8857, jim.gleason@glseq.com.

GLSEQ, LLC has been serving the nuclear industry for 28 years.

New paradigm non-intrusive cable condition monitoring method for Cable Aging Management Programs

GLSEQ introduces its patent pending Voltage Performance Integrity Condition Monitoring (VPICM™) which is a new paradigm non-intrusive cable condition monitoring method used to verify cable insulation integrity and to detect insulation degradation in insulated cables and associated splice, connector, and EPA in an electrical circuit.

VPICM™ has been a solution waiting on a problem.

The problem has arrived: Aging Management Programs (AMP) of cable for Subsequent License Renewal (SLR).

AMPs are required for Electrical Insulation for Electrical Cables and Connections in 10 CFR 50.49 Environmental Qualification and cables and connections not in 10 CFR 50.49, including I&C, Low Voltage, and Medium voltage cables.

VPICM™ is a solution that will save nuclear power plants significant costs over traditional cable tests since it is non-intrusive and non-invasive.

Most cable aging management processes rely on visual inspection, which is great when the cable is visible, however, miles of cables are not only not visible they are also inaccessible.

VPICM™ monitors the whole cable end-to-end including each splice, connector and EPA in an electrical circuit and captures events that demonstrate insulation integrity or detectable degradation.

VPICM™ metrics are compared to the metrics generated during the environmental qualification programs on the cables or on common industry requirements.

Contact: Jim Gleason 256-369-8857, jim.gleason@glseq.com.

GLSEQ, LLC has been serving the nuclear industry for 28 years.

www.glseq.com

BROKK®

Q: So how can you perform challenging, heavy duty, D&D work in Hazardous environments at nuclear sites in complete safety?

A: Well if you are familiar with BROKK remotely operated machines, you will know that over the past 40 years more than 10,000 BROKK machines have been deployed worldwide in the most hazardous of environments. Furthermore, you may also be aware that there have been no injuries incurred by operators using BROKK equipment deployed on some of the most challenging projects at nuclear sites worldwide.

We can all appreciate the significant negative impact to a project if there is an injury, a near miss, exposure to radiation or exposure to hazardous materials for any individuals engaged on the project. This negative impact may go beyond the project, to the overall site, even to the industry itself. The use of BROKK remotely operated equipment keeps the operators at a safe distance from the hazardous workface avoiding the possibility of injury or exposure.

BROKK Features and Benefits

An important advantage of BROKK equipment is high productivity, so safer does not mean slower. Very powerful tools are rapidly deployed by the BROKK machines to complete work effectively and to help bring projects in ahead of time and under budget.

BROKK offers hundreds of standard and custom designed tools and attachments for our machines to ensure that the best tools for the job are always available.

With these multiple attachment choices, compact size, ease of maneuverability and an intuitive control system, BROKK is now established as the nuclear industry standard for safe, powerful, reliable, rugged, high performance, remotely operated equipment. Our unmatched 40 years of deployment experience and the lessons learned from this have been incorporated into our latest generation of equipment. Many upgrades and improvements have been made to continually improve the performance of our equipment based on direct feedback and our extensive operational experience.

Innovative BROKK features such as our "NQH" auto-tool change interface avoids any operator radiation exposure on projects requiring multiple tools and a variety of functions to be performed by a single machine. Vision systems, additional radiation hardening and auto recovery systems are also available as integrated machine options where required.

BROKK Technical and Customer Support

BROKK has a dedicated internal Special Engineering Group to assist our customers in defining the best overall solution to meet the project goals. We continue to provide ongoing technical support for all of our customers after equipment delivery, through the duration of the project. We stock a full range of spare parts which are typically shipped out the same day as they are requested. We also provide on-site technical support and certified operator training at the customer's site(s) as needed.

BROKK Custom Design and Special Applications

The BROKK Special Engineering Group can also develop custom designed machines and custom designed attachments where needed for special projects. We have a proven track record of successfully working with our customers to develop and deploy application specific solutions.

For more information Contact Tony Marlow Tel: (505) 699 8923, email: tony.marlow@brokkinc.com, www.brokk.com/us

Extraordinary power and reliability for extraordinary jobs.

Some projects require a special solution. Brokk offers a unique and well proven combination of equipment, design, engineering and technical support for the most challenging projects at nuclear facilities.

Brokk is the industry leader for safe, rugged, reliable, heavy-duty, remotely operated equipment and with 8 available base machine options, there is a Brokk machine size available to suit each application without compromise.

Brokk machines are available with many standard options including vision systems, radiation hardening, auto tool change, auto recovery capabilities and more. They can also be customized and fitted with additional special options as needed for specific customer projects

Brokk also offers hundreds of standard and custom designed tools and attachments for our machines. With our standard quick change attachment interface or our optional fully remote tool change interface, a single Brokk machine can perform multiple tasks in hazardous environments with the operator always working in complete safety.

Now add to that over 40 years of Brokk deployment experience, our in-house engineering and technical support staff, on-site training and after sales support and you can see that Brokk provides comprehensive support to our customers who are working on very challenging projects.

For more information Contact Tony Marlow Tel: (505) 699 8923, email: tony.marlow@brokkinc.com

Original Demolition Power™

BROKK®

Brokk Inc. | 1144 Village Way, Monroe WA | Tel.: 360 794 1277 | info@brokkinc.com | www.brokk.com/us

MIRION TECHNOLOGIES

Mirion Technologies provides products and services for a wide range of radiation safety, measurement and scientific purposes.

Mirion solutions are employed in advanced space, technology and research applications as well as to secure critical facilities, protect people from radiation exposure and limit the spread of contamination.

Our organization is comprised of over 1700 talented professionals, passionate about delivering world class products, services, and solutions to our customers.

From our operating facilities across North America, Europe, and Asia, Mirion Technologies offers products and services in **6 key areas**:

- Health Physics
- Radiation Monitoring Systems
- Spectroscopy
- Characterization
- Dosimetry Services
- Sensing Systems

Sensing Systems Division

The Sensing Systems Division, maker of IST and IST-Conax range of products, offers a range of operational safety and non-safety radiation monitoring equipment, including in-core and out-of-core detectors and electrical penetrations. This equipment is used by power generation establishments to ensure the safe and efficient operation of their facilities. In addition, Mirion manufactures the associated electronics, temperature sensors, thermocouples, special purpose valves, connectors, cable/ connector assemblies and electrical conductor seal assemblies.

The entire Mirion team is dedicated to providing a new standard of solutions for our customers in nuclear facilities, military and civil defense agencies, hospitals, universities, commercial, state and national laboratories, and other specialized industries.

For more information about our wide range of products and services visit: **www.mirion.com.**

MIRION TECHNOLOGIES SENSING SYSTEMS DIVISION

Operational Safety & Non-Safety Radiation Monitoring Equipment

Out-of-Core Detectors, In-Core Detectors & Electrical Penetrations

*Proven quaility **SOLUTIONS** to meet your requirements*

Sensing Systems Division
315 Daniel Zenker Drive
300 IST Center
Horseheads, NY 14845 USA

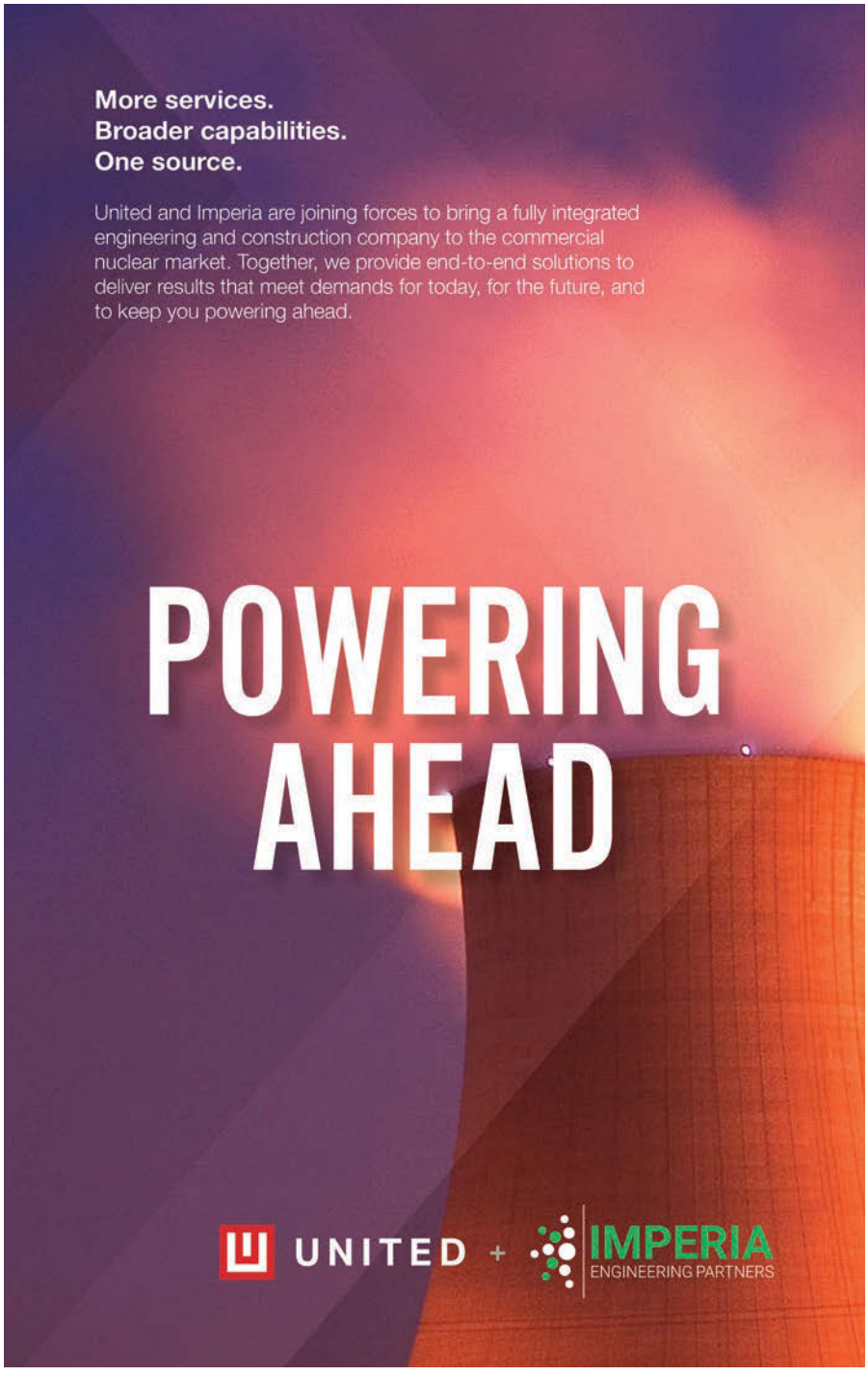
Phone: 607-562-4530
FAX: 607-562-4482
Email: ist@mirion.com

ist

UNITED + IMPERIA ENGINEERING PARTNERS

United Engineers & Constructors and Imperia Engineering Partners join forces to deliver a comprehensive solution center to the nuclear industry.

United Engineers & Constructors (United) and Imperia Engineering Partners (Imperia) have integrated to expand their joint capabilities. Imperia is now a wholly owned subsidiary of United and this integration enables Imperia and United to access each other's complementary capabilities in the engineering space and offer expanded EPC services. The result? A more comprehensive toolbox from which our clients can choose their solutions.



More Tools. Easier Access.
For example, United has construction capabilities and Imperia has a materials engineering laboratory. A team from United, consulting with a client about a modification to take place during an outage, now has access to Imperia's lab, which works with nuclear plants to forensically investigate failed components found during outages and is licensed to handle radioactive materials.

And a team from Imperia consulting with a client about implementing an engineering program such as flow accelerated corrosion (FAC) now has access to United's maintenance and construction force. Easy access to each other's unique offerings means a broader and more seamless set of solutions for the client.

More Expertise For Our Clients
The combined offering of United and Imperia includes engineering design, outage support, maintenance and modifications, in-service inspection (ISI), large component replacements, flow accelerated corrosion (FAC), decommissioning, microbiological induced corrosion (MIC), coatings and linings, new generation, and small modular reactors (SMRs), and much more.

The Industry Powerhouse
From new design and construction to forensic investigation of failed components, to implementation of engineering programs such as FAC, the integrated team of United and Imperia is the solution center for the nuclear industry.

Put this powerhouse resource to work for you.

For more information visit:
www.ueci.com and
www.imperiaep.com

Valcor: Designer and Manufacturer of High Quality Flow Control Devices

Valcor Engineering Corporation designs and manufactures valves for nuclear, aircraft, space, industrial, and scientific applications. Since 1951, Valcor's involvement with supplying components for difficult applications with high-pressure, flow, temperature, and vibration under extreme environmental/seismic conditions has been continually expanding. Today, Valcor manufactures over 100,000 solenoid valves and other fluid system components per year!

Valcor Engineering originally started out in the aircraft and space industries. Applications include both commercial aircraft and space components to major programs. We have also supplied hydraulic, fuel and pneumatic solenoid valves, APU shut-off valves, pressure and flow regulators, and pressure vessels for military programs including naval nuclear, fixed wing, rotary and unmanned aircraft.

In 1970, Valcor expanded and began designing and manufacturing high quality flow control components to the nuclear industry, with most activity centering on solenoid operated valves and regulators. Within Valcor, the Nuclear Group is structured as one of three integral corporate business units, which allows us to focus very clearly to develop, design and produce products for the nuclear industry worldwide, and be extremely responsive to individual customer needs. Our business is split approximately 50/50 between the domestic and international markets.

Most of our products are either ASME "N" stamped process valves for various fluids (including hydraulic fluid applications), or Class 1E air pilot valves for pneumatic actuators. There are also many special designs within our installed base of well over 15,000 "N" stamped units. Our products range in application from reactor coolant pressure boundary isolation to cryogenic, liquid sodium and marine (nuclear navy) services. These products generally are less than 4" NPS, and are used extensively in both domestic and international nuclear programs.

We have also signed license agreements and other supply arrangements with well-known former suppliers to the nuclear marketplace to manufacture and supply their unique nuclear product lines:

a. Hoke Inc. (Cresskill, NJ) for the supply of instrument isolation valves and manifolds

b. Circle Seal Controls (Corona, CA) for the supply of inline check valves and solenoid valves.

c. Fox Valve (E. Hanover, NJ) for the supply of cavitating venturis and eductors

d. CU Services (Elk Grove Village, IL) for the supply of plug resistant orifices and let down orifices

These relationships have greatly expanded our supply capability beyond our traditional ASME Section solenoid valves.

In 2020, Valcor underwent a highly successful ASME re-certification audit for our "N", "NPT" and "NS" certification/stamps. We are excited that this renewal now extends to welded piping systems, subassemblies, and component supports, and pressure vessels. This, in turn, opens significant new markets to us for the supply of complete systems, such as skid-mounted process packages requiring an extensive degree of installed instrumentation components.

For more information on our products and services, please visit www.valcor.com, call us at (973) 467-8400 or email us at nuclear@valcor.com.

At Razor Ribbon, Our Experts Secure Your Vision

Razor Ribbon® has proudly been the world's leading and longest standing manufacturer of barbed tape products since 1979, we offer great infrastructure solutions that protect. The Razor Ribbon Rapid Deployment Unit Trailers are about convenience and ease of use.

- Ability to deploy over 400ft (121 m) in less than 30 seconds
- Appropriate as a temporary barrier for emerging threats or as a perimeter barrier
- Retracts quickly and efficiently for reuse

To view our full line of solutions that can deter, delay and protect visit: **atkore.com/razorribbon**

Atkore Razor Ribbon

Distributed by: DuBose NATIONAL ENERGY SERVICES, INC.

Contact:
sales@dubosenes.com
910.590.2151

About ***Atkore - Razor Ribbon®***

Razor Ribbon is the world's leading and longest standing manufacturer of barbed tape products since 1979, and a domestic manufacturer in the United States.

The Razor Ribbon® line of barbed tape products is the optimal choice for perimeter security protection.

Manufactured for use in the most secure and restricted environments, Razor Ribbon® has enhanced security protection for a variety of industrial, military, and institutional facilities.

Our Razor Ribbon® products are razor sharp and can create serious cuts on anyone trying to climb over the barrier. The products are not only used as a physical barrier but also work as a psychological deterrent. Razor

Ribbon® is designed to deter, delay, and detect intruders.

Nationwide and international distribution | *Superior deterrence and security | *Manufactured from exceptionally tough, high-quality domestic stainless steel components with full traceability | *Available in Single or double coil spiral or concertina | *Available in various diameters and deployed lengths | *Large capacity with quick turnaround | *Product workmanship warranty | *Easy-to-install | *Unparalleled customer and technical support

About ***DuBose National Energy Services (DNES)***

*As the longest continuous ASME certificate holder (since 1977), **DNES** is proud to offer quality products with exceptional (24/7/365) service. **DNES** carries one of the largest, most diversified inventories of nuclear qualified material. **DNES** stocks bar, plate, sheet, structural shapes, pipe, tubing, flanges, fittings, fasteners, Unistrut® metal framing products, cable tray, weld rod and wire. **DNES** supports common carbon and alloy steel to highly corrosive-resistant stainless; nickel alloys to aluminum, copper and bronze. **DNES** also offers the Razor Ribbon® Barbed Tape product line for protecting physical assets, inventory and infrastructure of nuclear, chemical and correctional facilities.*

*In addition, **DNES** offers many value-added services from machining, fabricating, sawing, burning, cleaning, blasting, painting, heat treating, commercial grade dedication (including NDE), and reverse engineering. All services are offered under our comprehensive Quality Program that is based on ASME Section III, NCA/WA-3800 and 4000 and accreditation through our approved 'N-type' certificates (NA, NPT and NS) ; 10 CFR 50 Appendix B; ASME NQA-1; ANSI N45.2; CSA CAN3-N299.2/3 (without design, 2016 Edition) & MIL-I-45208A. Additionally, **DNES** is also accredited under AISC and AWS, as well as ASME Section VIII (Pressure Vessels, Division 1 – U & R Stamps.) **DNES** has fleet contracts with most of the large nuclear utilities.*

ROS
REMOTE OCEAN SYSTEMS
A LEADER IN NUCLEAR INSPECTIONS

REMOTE OCEAN SYSTEMS is a leader in the design and manufacture of reliable, radiation-tolerant lighting and inspection systems for fuel pool and reactor visual inspections since 1975. Our product line includes rad hard cameras, high intensity pool lighting and high accuracy, robust pan & tilt positioners. Our cameras offer high resolution and high-definition output with optical zoom for close-up inspections. We offer both stationary pool lighting with LED or high-pressure sodium lamps plus LED drop lights. Our new CEX-HD Inspection System combines a high-definition camera with dual LED lights for brilliant, HD images and includes a compact, state-of-the-art IC-Link Controller that features system diagnostic capability and links to a joystick for precise control over zoom, focus and exposure as well as control of lighting and camera operation. Remote Ocean Systems offers a fully staffed engineering department to help with your special inspection requirements.

New compact design IC Link Control Box includes self-monitoring feature and connects to a USB Joystick for fast, easy and accurate camera control.

For more information on the new CEX-HD Inspection System
Contact: sales@rosys.com or visit www.rosys.com

ROS
REMOTE OCEAN SYSTEMS
A LEADER IN DEEP SEA LIGHTING

Take a Close Look at The New ROS CEX-HD Inspection System

A State-of-the-Art High Definition Camera and Control System that Helps You See and Prevent Costly Downtime Problems.

■ *The CEX-HD camera features 1080p resolution and 30:1 zoom capability.*

■ *New compact design IC Link Control Box includes self-monitoring feature and connects to a USB Joystick for fast, easy and accurate camera control.*

Nuclear industry leader for over 50 years

The Energy and Nuclear industry has sought Teledyne Brown Engineering's support for over 56 years as a leader in providing innovative systems engineering, cutting edge technology, radiological analysis, and advanced manufacturing solutions. The company's strengths in both engineering and manufacturing, first-of-a-kind and one-of-a-kind systems and components, along with stringent quality standards, enable them to provide customers with crucial solutions.

Teledyne's Radiological laboratory performs over 60% of the environmental radiological sample analysis for the US commercial nuclear power plant fleet. It also supports international power plant customers, decommissioning facilities and locations being remediated.

Teledyne's Radiological laboratory performs over 60% of the environmental radiological sample analysis for the US commercial nuclear power plant fleet.

Teledyne also possesses a laboratory that develops and manufactures extremely sensitive noble gas monitoring equipment. These systems sense the atmosphere for evidence of underground nuclear detonations in support of the comprehensive nuclear test ban treaty. This team was recently recognized by the Federal Laboratory Consortium for Technology Transfer and won an R&D 100 award for commercializing the government laboratory prototype system for international use.

Teledyne Brown Engineering also supports projects of varied sizes for the National Nuclear Security Administration and the Department of Energy. They are involved in the development of designs and components for Advanced Nuclear Reactors including small modular reactors, micro reactors, and fusion reactors. The company has maintained a variety of ASME stamps and certifications allowing them to perform work and build systems according to nuclear industry specifications and standards.

BECHTEL

ENERGY
INFRASTRUCTURE
MINING & METALS
NUCLEAR, SECURITY & ENVIRONMENTAL

U.S. Plant Vogtle Units 3 & 4

Natrium™

Relentless Drive to Deliver for Our Customers

Enabling the transition to resilient, reliable, low-carbon energy. Building safety and efficiency. We share these missions with our partners in the U.S. and across the globe.

Toward a resilient, sustainable future

It takes more than bold thinking to commit to a carbon-free energy transition. But the world is doing just that.

It takes more than renewable energy to power the electrification of transport, the replacement of fossil fuels, and the development of emerging economies. But forward-thinking nations are making plans.

It takes more than brilliant engineering and design of advanced nuclear reactors, but our industry partners have done it.

It takes more than money. But the funding is there.

It takes more than 60 years of experience in civil nuclear power, which Bechtel has.

Bringing it all together

When these things come together – bold thinking, all-of-the-above electricity generation, brilliant engineering, innovative financing, and decades of experience – something special happens.

Today in Georgia, Bechtel is completing construction of Plant Vogtle Units 3&4, helping Georgia Power realize its vision of powering 500,000 homes and businesses with carbon-free electricity.

Wyoming has taken bold steps toward placing the Natrium advanced reactor at the site of a retired coal-fired power plant. Natrium's molten salt heat storage perfectly complements intermittent generation from solar and wind. Bechtel is proud to be TerraPower's EPC partner.

At the Idaho National Laboratory, Bechtel is the EPC partner for the Versatile Test Reactor – a critical tool to discover, test, and advance the technologies we need to help our planet prosper.

Our commitment to you

Bechtel has spent more than a century helping customers navigate shifts in energy consumption, technological change, financing challenges, and a sharpening focus on resilient, sustainable alternatives.

Our commitment to you is to help turn today's political and social momentum for energy change into a reality, and work together to ensure our planet thrives for many generations to come.

Learn more.
Contact us today at Bechtel.com

Specialized Nuclear Workforce Solutions and Turnkey Services

For over 40 years, System One has provided workforce solutions and turnkey services to the nuclear power industry. Our customers include domestic utilities, government laboratories supporting the US Departments of Defense and Energy, NSSS OEMs, EPCs, and other specialty manufacturers and service providers within the nuclear energy industry. Our knowledge and focus within the industry has led to consistent year over year growth making us one of the top 3 providers in the US.

exceptional talent. specialized solutions. **systemone.com**

Workforce Solutions

We design and deliver workforce solutions to meet our customers' unique needs for contract and permanent staff, whether for single placements or high-volume engagements. Our dedicated "nuke squad" team of operations staff and recruiters, coupled with advanced technologies, quickly deliver the talent needed for plant operations, capital projects, new construction, repair and maintenance, refueling outage services and plant decommissioning. Our capabilities provide:

- Technical talent with the necessary credentials including security cleared personnel up to the top secret level
- Scale and flexibility through our Managed Staffing Program and Recruitment Process Outsourcing models driving speed and cost-savings
- Integrated talent workflow with other providers through our proprietary VMS technology to simplify the delivery process across all stakeholders

Turnkey Services

Our turnkey services are customized to meet our customers' varying needs across a wide spectrum of specialized and technical capabilities including:

- Advanced NDE including PT, MT, VT, Microwave, UT and RT, including PAUT and computer-aided RT services via our exclusive partnership with Evisive, LLC
- QC inspection services delivered by certified personnel
- NDE, QC, CWI and pipeline inspection training at our certified training center
- Management resources for construction and capital projects, including smart meter installation, smart grid integration services, project scheduling, and project controls

Learn more at systemone.com or contact us at nuclear@systemone.com

BLACKSTARTECH®

Targeted Power and Lighting. Anywhere. Anytime.

BlackStarTech® provides a wide variety of industrial, state-of-the-art battery power sources and lighting solutions – as a comprehensive asset protection suite or as individual assemblies – to address tactical power and lighting delivery needs in a compact rapidly deployable configuration.

The **Genesis Series Emergency Power Systems** and the **Lightworks™ Series Lighting Solutions** can be immediately deployed nearly anywhere to augment FLEX Response, deliver targeted battery power supplies and provide battery powered illumination where they are critically needed.

Deployed in less than 30 minutes, our two-step restoration process first energizes targeted loads for 8 to 12 hours. Then our integrated compact backup propane generators are connected to keep the equipment powered for up to 30 days.

BlackStarTech® significantly enhances safety margins, improves facility PRA, increases resiliency factors and provides productivity and cost savings solutions for a variety of maintenance and outage activities.

Come see us at the ANS Utility Working Conference and Technology Expo, Booth #102

August 8 - 11 | Marco Island, FL

Scan the QR code below for more information.

www.**blackstartech**.com

Exelon PowerLabs®

AVANTech Steel Containers (ASCs) Provide Tremendous Savings

AVANTech, LLC has recently announced several new contracts for AVANTech Steel Containers (ASCs) for radioactive waste disposal, saving some nuclear power plants and other nuclear facilities over ~200K/year – a 25% liner savings year-to-year.

While raw steel prices have increased +10% over the last year and continue to rise, AVANTech has been proactive and added efficient fabrication equipment for production of dewatering/waste liners.

AVANTech has recently invested in liner shell plate, angle, and pipe rolling machines; Computer Numerical Control (CNC) mills; and precise waterjet abrasive cutting systems. This machinery increases production efficiency and reduces waste material, while allowing AVANTech to pass on these cost savings to customers.

Cost reduction strategies include:

- ➢ Raw material steel costs have been reduced by 25% because of the tooling obtained.
- ➢ Raw material filter costs are being redesigned/evaluated.
- ➢ Labor cost reduction team developed to create jigs to speed up assembly and modify designs to reduce weld time by 50%.

AVANTech's complete line of ASCs is available in all common sizes: 8-120, 10-160, 14-170/190, and 14-200/210/215, etc.; or can be built to custom specifications. All ASCs are high-quality, IP-1 packages and are designed to maximize internal usable volume. This results in more radioactive waste being shipped in each outgoing shipment, which contributes to fewer shipments and less costs.

The ASC dewatering/waste containers are compatible with existing fleet dewatering equipment (e.g., SEDS, RDE, etc.) as well as all remote container grapple systems. The ASCs are a direct OEM replacement and are capable of being gross dewatered or fully dewatered to meet the stringent Free-Standing Liquid requirements for direct commercial radioactive LLW burial.

AVANTech is also expanding alternatives for radioactive waste management cost savings:

- ➢ Liner-in-Liner (LNL™) Downblending Containers *(Patented)*: ~$150,000 Savings for each liner downblended.
- ➢ Volume Reduction Container (VRC™) Collapsible Radioactive Wet Waste Liner System *(Patent Pending)*: ~20% Savings
- ➢ 800-gpm High-Flow Pressurized Solids Collection Filter (SCF™): Reduces outage time

AVANTech offers radioactive and industrial water treatment solutions with advanced fabrication facilities in Columbia, SC; Richland, WA; and Knoxville, TN. AVANTech has extensive experience creating integrated solutions in industrial, government, and nuclear power applications.

Ready to See Your Nuclear Facility in a Different Light?

BIRNS has been providing high performance lighting solutions for the nuclear industry for the last five decades. Our industry-leading underwater floodlights, camera lights, emergency lights and high and low bay lights provide powerful illumination for safer, more efficient working conditions throughout the plant. With low power draw, high light output, long lamp lives, and advanced safety features and qualifications, BIRNS lighting is field-proven and trusted worldwide.

The new BIRNS Lumena-6™ LED underwater floodlight provides powerful, precision high efficiency illumination. Its 85,000 lumen output and 80,000 hour lamp life provide long term use, delivering brilliant near daylight visibility to fuel pools, transfer canals and other key applications. Precision engineered with an integrated, water cooled power driver and ultra-high efficiency reflectors, this plug-and-play system draws only 600W and operates on any mains supply from 90 to 300VAC, providing scalable and highly effective lighting to maximize safety and brilliance. The BIRNS Lumena-6 is custom-designed with BIRNS' 40+ years of nuclear lighting experience–we know you'll like what you see.

QUALITY SYSTEM CERTIFICATION DNV·GL ISO 9001

BIRNS' Quality Management System is ISO 9001:2015 Certified; NRC 10CFR50, App. B Compliant

BIRNS®

High Performance . . . Under Pressure®

www.birns.com

Ludlum Measurements:
Leading the way since 1962

Ludlum Measurements, Inc. (LMI) has been a designer and manufacturer of quality radiation detection equipment for the Health Physics Industry for almost 60 years. Through the years the health physics industry has grown and expanded into many different industries, including the oil and new and recycled metal industry, university and medical research labs, as well as the traditional market, which includes local, state, and federal agencies. With this growth in the industry, the line of products LMI offers has grown as well.

LMI's primary manufacturing facility in Sweetwater, Texas is fully integrated and offers customers a full line of products and services, including custom instrument design and manufacturing. They also offer repair and calibration services for their own products, as well as many of their competitors' products.

After leaving Eberline Inc. in 1961, Don Ludlum, the company's founder, looked around West Texas for a community to start his business. While not initially on his list of towns to consider, a chance stopover due to bad weather led him to Sweetwater. He ended up choosing Sweetwater for many reasons, but most importantly for its open and welcoming attitude. It also offered many things he needed for his small company.

His first manufacturing plant was located at 1210 Broadway where the company operated until they outgrew the facility and relocated to their current location at 501 Oak Street in 1975.

From then on, the company has continued to grow, leading them to now own 11 different subsidiaries that not only cater to many different companies with an extensive number of products and services, but to cater to LMI competitors as well. LMI also prides themselves on insourcing a very large percentage of their components used in manufacturing their product lines.

The following timeline provides an overview of the various acquisitions over the years:

- 1992: acquisition of ADIT, a photomultiplier tube designer and manufacturer
- 1996: formation of Eljen Technology, a developer and manufacturer of organic plastic scintillators
- 2000: formation of West Texas Molding, an injection molding company
- 2007: acquisition of ET Enterprises (formerly Electron Tubes), a designer and manufacturer of photomultiplier tubes based in the United Kingdom
- 2010: formation of Ludlum Wind, a product line that specializes in wind turbine components
- 2011: acquisition of Protean Instrument, a designer and manufacturer of high performance alpha-beta sample counting systems
- 2012: acquisition of Plowden & Thompson / Tudor Crystal, a manufacturer of glass and glass products based in the United Kingdom
- 2018: acquisition of 2B Technologies, a designer and manufacturer of portable instruments for air monitoring, environmental and industrial applications
- 2020: acquisition of Ludlum GmbH (formerly James Fisher Nuclear GmbH), a designer and manufacturer of contamination and clearance monitoring systems based in Germany
- 2021: formation of Ludlum Systems, the distributor and service provider for Ludlum GmbH products in the United Kingdom

Ludlum Measurements is a true entrepreneurial success story. From its meager beginnings in the kitchen of Don Ludlum's family home in 1962, it has grown into a leading provider of radiation detection equipment worldwide.

MarShield Nuclear is a Premier North American Manufacturer of Nuclear Radiation Shielding Products and Solutions.

With over 40 years of experience established in 1979 MarShield an ISO 9001:2015 registered company supplying Radiation Protection Shielding Solutions to the nuclear and medical industry worldwide.

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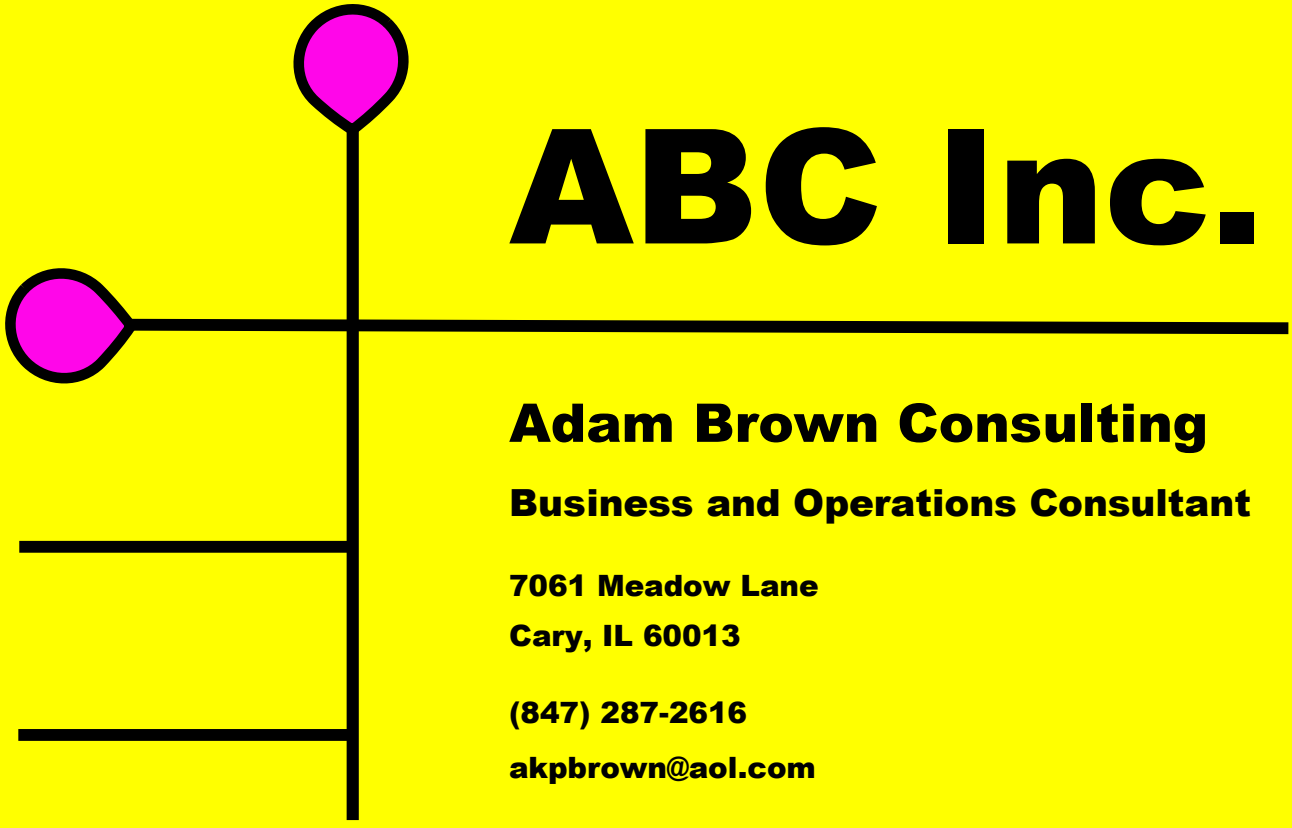

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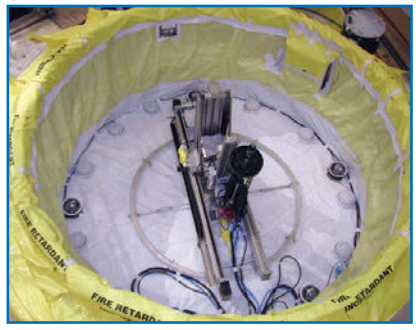

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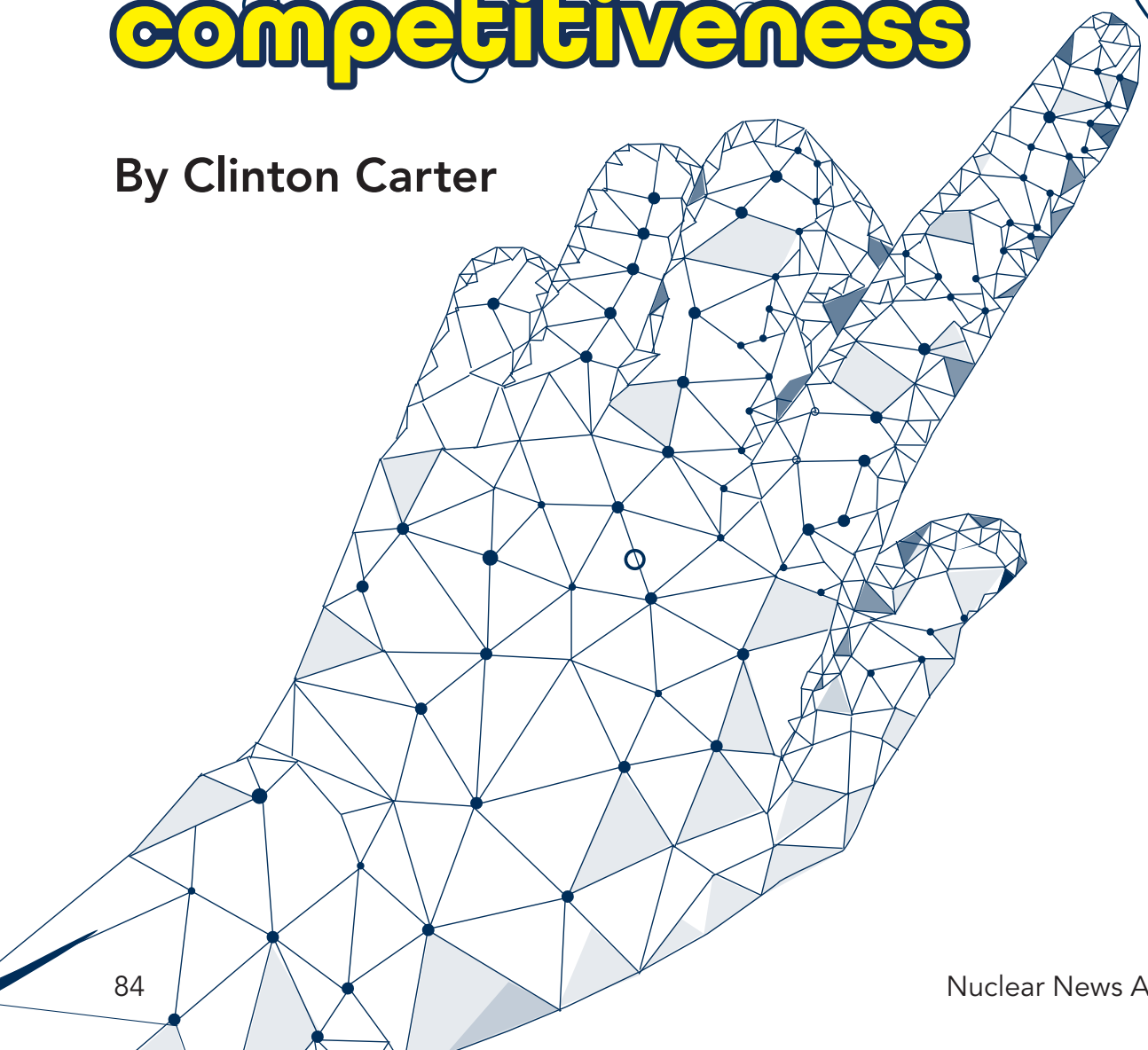
USA's ARM extends a hand in preserving nuclear competitiveness

By Clinton Carter



It is no secret that the nuclear power industry is enduring an economic crisis. Brought about largely by the impact of technological disruption across the larger energy market, a number of utilities have had no option but to prematurely shut down some nuclear plants because they could no longer compete in the regions they serve. Many others are similarly at risk.

In the midst of today's economic realities, the Utilities Service Alliance (USA) has launched an ambitious initiative: the Advanced Remote Monitoring and Diagnostics Services Project (ARM). ARM is a multi-million-dollar research and development initiative funded through a cooperative agreement with the Department of Energy Office of Nuclear Energy's Advanced Reactor Development Projects pathway. ARM promotes a vision that our nation's nuclear energy supply can be preserved by transforming core business processes through the application of advanced technologies. John Christensen, USA president and chief executive officer, noted, "USA is in a unique position to not only help our member utilities, but we are making a commitment to share our learnings and opportunities with everyone in the nuclear industry. For any of us to succeed we must all succeed."

USA is a not-for-profit cooperative whose mission is to reduce operating and maintenance costs, improve safety and performance, and provide innovation and leadership within the nuclear power industry. Membership includes eight nuclear utilities operating 14 reactors with a combined generating capacity of over 15,000 MWe.

As a part of the ARM industry demonstration, four of USA's member utilities are working alongside national laboratories, academic researchers, and leading technologists to research, develop, and deploy advanced monitoring solutions across a number of their facilities. This work will enable automation of data collection, analytics, and anomalies detection through intelligent machine learning algorithms. The project also aims to demonstrate the value of integrating all of these new capabilities into a centralized, 24-7 remote monitoring and diagnostics (M&D) center.

Idaho National Laboratory is a key partner in this initiative. INL's team is leading research activities associated with developing intelligent software tools that will aid in the analysis of plant telemetry and recognize the emergence of unusual conditions warranting human attention. INL also coordinates and oversees project-related research activities going on at selected universities. Bruce Halbert, director of the DOE's Light Water Reactor Sustainability Program, said, "Enhancing the economic competitiveness of operating nuclear power plants is vital to ensure their long-term operation. These projects led by USA will enable the domestic nuclear fleet to employ advanced technologies to be and remain competitive in current and future energy markets."

ARM is all about industry transformation and modernization of practices. Many long-standing nuclear programs such as plant health monitoring, equipment inspections, and compliance-related activities were designed many years ago before the proliferation of the Internet, wireless telecommunications, and intelligent software systems. These legacy processes, while highly effective, are complex and require a large investment of costly human resources to manage. Transformation of these processes through the application of modern technologies offers an opportunity to improve efficiencies, eliminate human error, and reduce operating costs.

With the mission of demonstrating how technological transformation can be achieved, ARM's research, design, and development activities are aligned with three foundational principles—standardization, automation, and centralization. The following discussion describes the complementary application of these principles in the various ARM project deliverables.

Continued

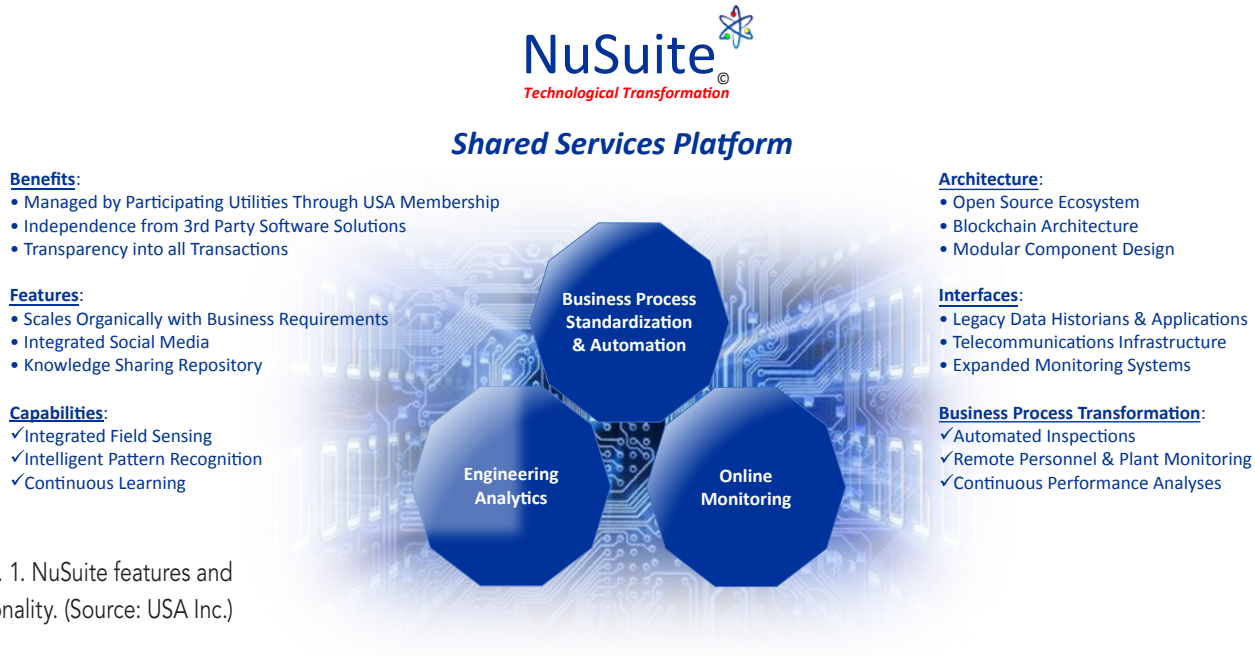


Fig. 1. NuSuite features and functionality. (Source: USA Inc.)

NuSuite

Operating cost reductions will be realized through standardization, modernization, and codification of nuclear plant activities. NuSuite is a shared services software platform capable of hosting various technologically redesigned business processes. The ARM project is developing a foundational prototype of this platform. Within the platform will reside a suite of standardized business applications, called modules. Every sub-tier project being developed within the ARM scope will be hosted in its own unique module. Each module will be composed of the user interface, record management system, calculational algorithms, and analytics based upon first principles and intelligent prognostics. The platform is envisioned to be structured as open source, wherever practical; inherently scalable; and owned by the participating utilities through USA membership. Figure 1 provides an overview of NuSuite's targeted functionality.

Business process transformation

Business processes will be transformed through the expansion of plant monitoring and analytical capabilities. This involves the deployment of various field-sensing technologies, telecommunications systems, and advanced algorithms in support of eight pilot projects. These projects were originally selected based upon an industry working group evaluating the potential economic benefits of remote monitoring technologies as a part of the Delivering the Nuclear Promise initiative being sponsored by the Nuclear Energy Institute. The ARM project is designed to demonstrate these technologies, develop an integrated approach to scale, and evaluate potential return on investment. Table 1 provides a listing of projects and the associated participating utilities. The projects listed in Table 1 and their related NuSuite modules capabilities are further detailed below.

Table 1 - ARM Pilot Projects and Participants

					
Project Participants	Utility / Station	Energy Northwest / Columbia	Talen Energy / Susquehanna	Xcel Energy / Prairie Island, Monticello	Vistra/Luminant / Comanche Peak
Pilot Projects	Operator Rounds Reduction				✔
	Technical Spec Shiftly Surveillances				✔
	Fire Protection Compensatory Measures		✔		
	Centralized Radiological Monitoring				✔
	Thermal Efficiencies and Cycle Losses	✔	✔		✔
	Process Anomalies Detection			✔	
	Transformer Health Monitoring	✔			
	24-7 M&D Services	✔	✔		✔

Operator rounds reduction


Lead: Comanche Peak

Operating staffs spend an extraordinary amount of time performing various plant tours and inspections, the primary goal of which is to simply verify that plant conditions are as expected. Technology holds the key to accomplishing such tasks, enabling operators to invest their time in more valuable activities. This project targets reducing the operator's burden through the deployment of advanced field-sensing technologies throughout the plant. These sensors include video, acoustic, temperature, humidity, radiation, vibration, smoke, and gas. Telemetry will be gathered through existing plant networks combined with broadband wireless. When something in the plant environment exceeds established thresholds, this NuSuite module will generate alarms alerting a monitoring station to the need to investigate and dispatch the necessary personnel.

Compliance automation—shiftly surveillances


Lead: Comanche Peak

This project demonstrates the ability to improve efficiencies by eliminating the need for deploying plant operators to manually walk into more than 100 rooms and areas each shift to read local analog gauges and perform inspections as required by plant technical specifications. Wireless sensors will be installed in these areas, eliminating the need for manual collection of readings. Telemetry will be transmitted through the in-plant wireless network. The surveillance will be initiated on demand by control room personnel. When activated, this NuSuite module will trigger data collection, perform analysis to verify acceptance criteria are satisfied, and then generate surveillance reports ready for supervisory review and approval.

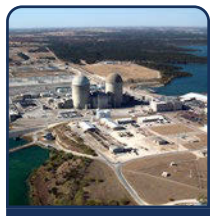
Continued

Fire protection compensatory measures

Lead:
Susquehanna

This project targets the elimination of costly manual roving and dedicated fire watch processes in favor of an automated detection system. Using advanced sensing technologies combined with artificial intelligence, this mobile system will enable the recognition of an emerging fire in areas monitored as a part of compensatory measures when required. The system's artificial intelligence algorithm, being developed through INL, will discriminate between an actual fire and certain routine activities, such as maintenance activities involving welding or grinding. Once a potential fire is recognized by the NuSuite module, the system will generate and transmit alarms and notifications over an in-plant wireless system to a dedicated monitoring center.

Centralized radiological monitoring



Lead:
Comanche Peak

Environmental monitoring of radiological areas and radiation worker oversight from a centralized facility will be automated as a part of this scope with the goal of reducing manual radiation surveys, inspections, and personnel monitoring. This approach also reduces occupational radiation exposure of plant personnel. The NuSuite module will display conditions in areas monitored and generate alarm notifications when thresholds are exceeded.

Thermal efficiencies and cycle losses

Participants:
Columbia, Susquehanna, Comanche Peak

This new capability replaces periodic walkdowns and testing to identify, quantify, and correct thermal losses in a near-real-time format. Wireless sensing technologies are being installed throughout balance-of-plant systems along drain lines and other possible leakage pathways. This in combination with online thermal efficiency calculations will be encoded in this project's NuSuite module, enabling near-real-time identification of energy losses, including location, severity, and economic impact information. When efficiency losses are detected, alarms will be transmitted to a remote monitoring center for evaluation and initiation of corrective action.

Process anomalies detection

Participants:
Prairie Island, Monticello

This NuSuite module will utilize artificial intelligence being developed by INL to detect emerging anomalies in nuclear plant operations. The system will discriminate between instrumentation issues and actual plant process changes, enabling early assessment of plant asset health conditions or any potential sensor drift issues. Alarms will be generated and transmitted to a remote monitoring center.

Transformer health monitoring

Lead:
Columbia

Using online dissolved gas analyzers combined with intelligent algorithms developed by INL, the health of large power transformers will be continuously monitored through this NuSuite module with prognostic alarms being transmitted to a remote monitoring center when adverse transformer conditions are recognized. This particular project offers a view as to how component and system health programs can be transformed through the application of technology and centralization of technical services through the use of advanced M&D.

Fig. 2. Luminant's Power Optimization Center. (Photo: Luminant)

24-7 M&D services

With the goal of demonstrating how centralized M&D services can assist in improving power plant safety, generation, and reliability while reducing a plant's overall operating expense, Luminant's Power Optimization Center (POC) is providing 24-7 advanced M&D services to Columbia, Susquehanna, and Comanche Peak as a part of the ARM project.

Participants:
Columbia, Susquehanna, Comanche Peak

The POC is also expanding capabilities to accommodate the additional plant-level projects previously referenced and providing consultation in support of developing each project's NuSuite modules. This aspect of the project represents a breakthrough benefit by demonstrating opportunities for centralizing engineering and technical services across a fleet of nuclear operators. Such an approach, when expanded to scale, equates to meaningful operating cost reductions. "The specific technical pilots are at the heart of this project, but it is clear that the monitoring and diagnostics service also provides a value that is significant to our members. We believe this service is icing on the cake and pays for itself in short order," Christensen said.

The POC has been in operation for over 15 years and is presently servicing more than 50 generating assets, including coal, natural gas, nuclear, solar, and battery storage facilities across the nation.

Continued

Value capture and sharing experience

In order to share project learnings with the larger industry, an objective review of the value contributions realized by ARM will be performed. This includes the development of a proposed strategy, industry roadmap, and supporting business case for scaling the solution to full production levels.

Progress thus far

As the ARM project enters its second year, engineering modifications are progressing, equipment is being installed in the plants, and meetings with potential technology suppliers are underway. At INL, research and development activities are in full gear with data scientists evaluating best approaches for developing intelligent algorithms in support of the NuSuite modules.

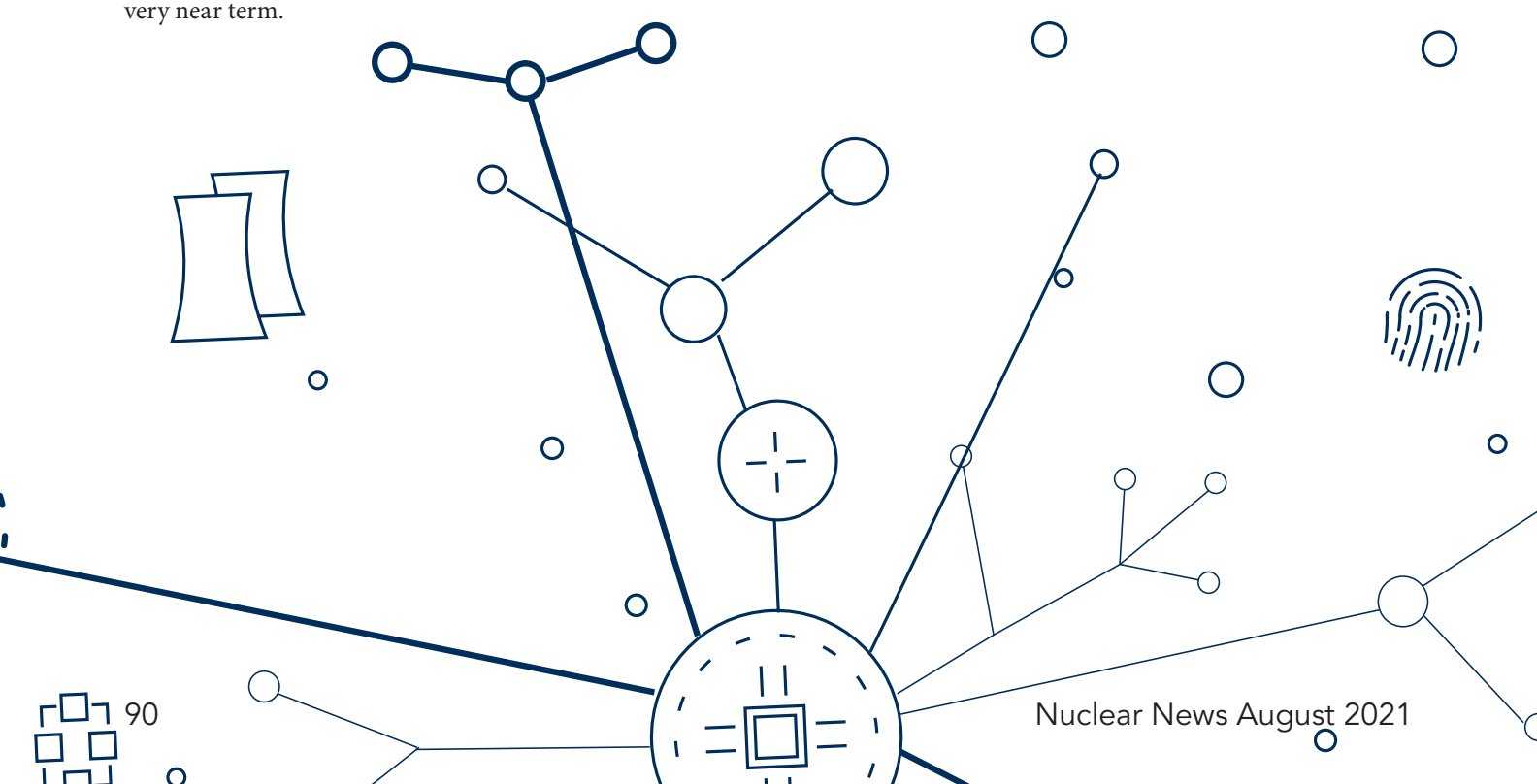
A prototyping laboratory has been erected at Comanche Peak, where field sensors of all types, telecommunications equipment, and expert technologists and plant personnel are constructing systems to be deployed. The POC has successfully implemented full-scale, 24-7 M&D services for Columbia Generating Station. The POC is also working on systems setup, advanced pattern recognition models, and cyber-secure networking interfaces in preparation for onboarding Susquehanna Steam Electric Station in the very near term.

Path forward

The early success of ARM is capturing the attention of others across the industry, including potential research partners, suppliers, and various industry organizations. Back at USA, during the most recent board of directors meeting, all eight utility members agreed to collaborate in the development of a proposal for a phase 2 DOE grant application. Phase 2's scope includes expanding the tools originally developed through ARM, further business process automation, including the utilization of drones and robotics, and expansion of the capabilities inherent in the NuSuite platform. "The early success and value of phase 1 of this ARM project has demonstrated to our board that we can be successful in managing and implementing a large, coordinated effort like this. That confidence has energized the group around phase 2 of the project, which will further drive value for our members and ultimately for others in the industry," Christensen said.

As so often is the case in challenging times, the teamwork and collaboration being demonstrated as a part of the ARM project represents the nuclear power industry at its best. Through ARM and other such industry efforts, we will succeed in maintaining our economic competitiveness as well as preserving the inherent benefits of nuclear power for our nation and all of humankind.

Clinton Carter (ccarter@usainc.org) is the director of fleet modernization for the Utilities Service Alliance.



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PowerLabs, Paragon, *and the* Parts Quality Initiative

By David Mueller

I still clearly remember a day in 2005. I was sitting at my desk when my boss at the time, Roosevelt Groves (then supply director of operations at Exelon), called me into his office with a select group and announced that we needed to figure out this "parts issue thing."

Why was this "thing" such a pressing issue that it required an impromptu meeting? It was because manufacturing defects were having a significant impact on Exelon's reliability. And this problem was well out of our direct control.

Resolutions to problems can be tackled in a variety of ways. Sometimes great ideas are captured on napkins. Some are drawn on blackboards. But fixing this parts issue was going to be a challenge, and the real question was, where could we start with an issue so far out of our team's direct control? At Exelon, we already had a robust supplier performance process, so our suppliers knew we would react and provide immediate feedback if there was a problem. What could we do beyond continued communication with our suppliers? We did, in this case, find a better solution.

With the help of Exelon PowerLabs, a small team of individuals quickly evaluated the trends, or as we called them, the "bad actors," which really meant the type and manufacturer of the components that had the most negative impact on our nuclear power plants. This analysis helped define a much smaller and more manageable scope of the problem parts and enabled us to develop a process that would include an independent and more rigorous test of suspect components before receipt and, more important, prior to installation.

We dubbed the resulting new program the Parts Quality Initiative, or PQI. Launched in 2006, the program had an immediate positive impact at Exelon. We experienced a dramatic drop in plant events caused by parts quality issues. In fact, in 2018, the Nuclear Energy Institute awarded its Top Innovative Practice Award to Exelon for this initiative.

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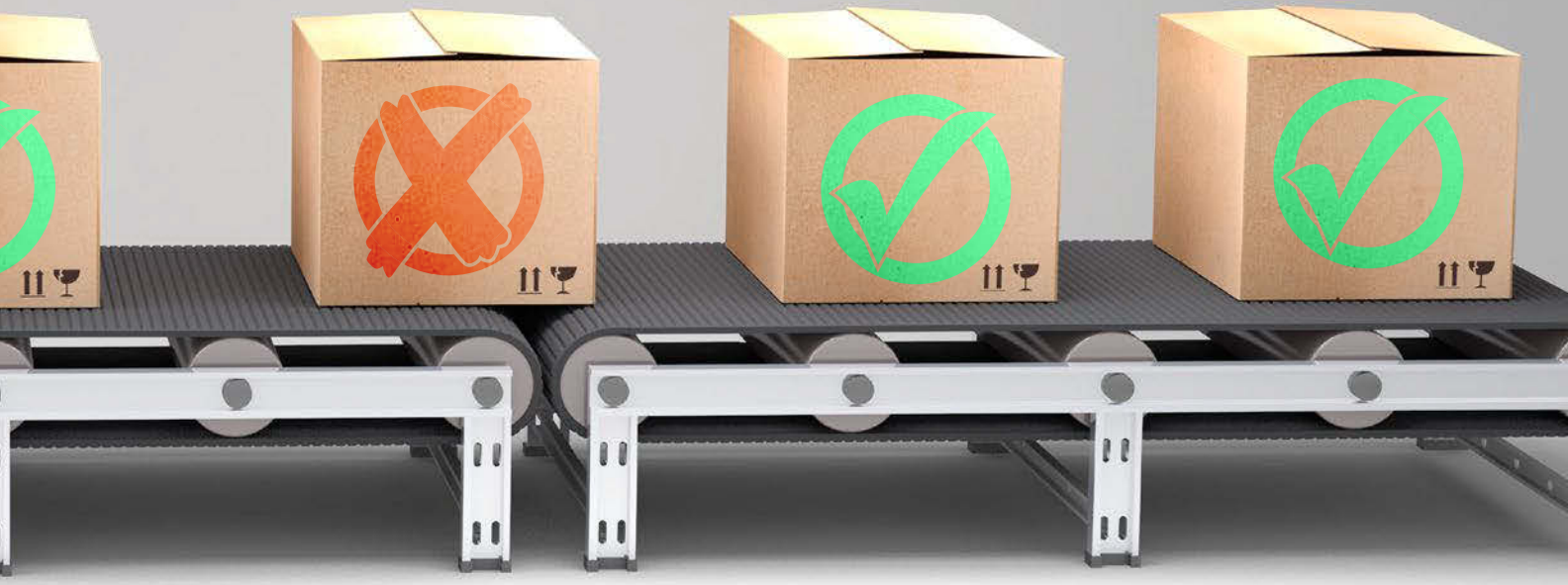
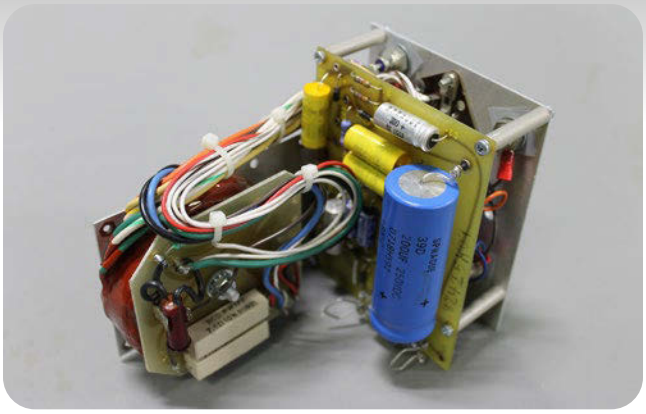
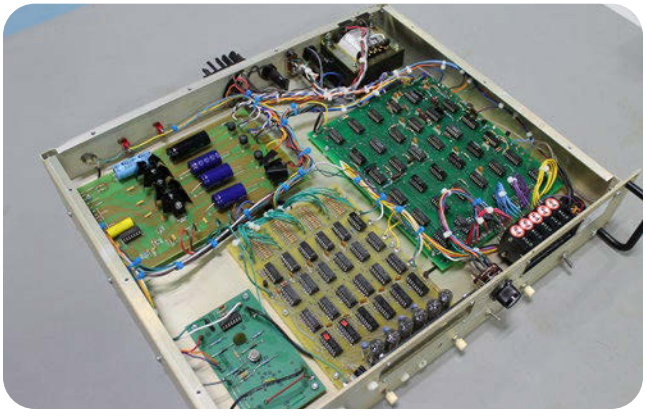




Power supply with electrolytic capacitors provided for repair by Exelon's Ginna nuclear power plant. Rochester Instruments P/N: 1003-853, 125VDC input +/-12V output. This is a good candidate for parts quality testing.

Power supply with electrolytic capacitors provided for repair by Duke, Westinghouse P/N: 475031 120VAC input +/-15V and -22V output. Another good candidate for parts quality testing.



Timer control provided for repair by Duke, Westinghouse P/N: 1530/ST101.

Since that 2005 challenge from Roosevelt Groves, parts quality has been part of my DNA. The topic comes up in almost all of my conversations, both internally with my co-workers now at Paragon, as well as in my numerous meetings and visits with industry customers. Parts quality is at the core of what nuclear supply is all about. More specifically, the goal is to provide facilities a quality part that will reliably perform its intended use.

The PQI is a plantwide, continuous learning process that uses internal and external operating experience to drive the testing of parts that are critical to safe and reliable plant operation. This crucial testing process ensures that parts reliably perform their operable functions once installed. Or more directly to the point, testing improves equipment reliability and reduces generation losses via proactive identification of poor-quality parts and components prior to installation.

At Paragon, where the PQI continues, we assist and provide oversight to the industry as stakeholders look to implement their own parts quality programs. While it can be said that there is no one type, cookie-cutter way to perform a parts quality process, it is true that doing nothing or not directly addressing the issues of parts quality is not the answer either.

Paragon chooses to be transparent in its process and attack the issue head on. Its approach is to first work with the customer, understand existing processes, and then design and implement a program aligned with that specific nuclear plant or utility. The bottom line is to design a parts quality process that will work for that plant.

Lori McGuire, parts quality process lead at Energy Harbor, spoke about the initiative. "The parts quality program is helping Energy Harbor take the next step in achieving equipment reliability excellence," she said. "Quality testing of critical parts has prevented two single point vulnerability failure opportunities in the first two months of program implementation. The parts quality program was also used to test a relay that has historically performed poorly in our chiller applications, and when 10 of 12 new relays failed parts quality testing, engineering initiated an evaluation for a replacement that would improve overall chiller performance and reduce repetitive failures in non-critical applications. It is rewarding to see firsthand how the parts quality program is improving the reliability of our nuclear fleet."

The PQI has provided the industry a unique and improved view of those potentially suspect parts. PowerLabs is engaged with the vendors early in the process

in order to solve problems from the start. This works to ensure that delivered components are of high quality and are reliable.

John Makar, Exelon senior supply operations specialist, speaking about the need for better quality in the manufacturing of parts, said, "That affects not just us; it affects the whole industry."

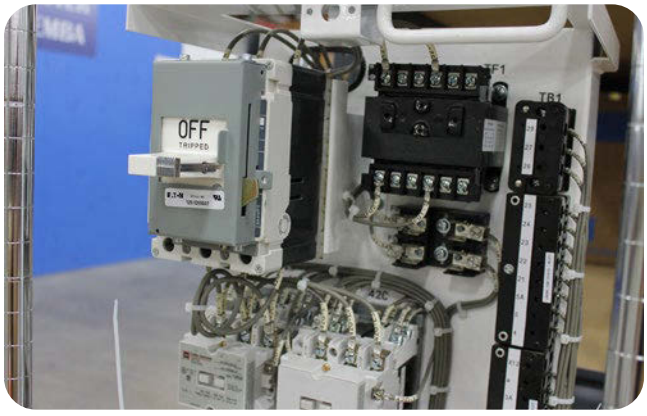
Makar explained that the PQI is viewed by the fleet senior leadership as one of Exelon's equipment reliability pillars. "The PQI, along with other equipment reliability initiatives, such as preventive maintenance optimization, single point vulnerability elimination, and rework reduction, has been successful in driving significant fleet performance improvements." Exelon fleet performance leads the U.S. nuclear industry in scram reduction, as well as capacity factors. The report on U.S. nuclear capacity factors in the May 2021 issue of *Nuclear News* (page 28) indicates that in the period 2018–2020, the top three performing reactors were Exelon units; furthermore, 10 of the top 20 performers were Exelon units.

"The most effective PQI programs test the subject components as soon as they hit the warehouse receiving dock, as part of the receipt inspection process," Makar added. "An often overlooked, value-added aspect of PQI is that the testing ensures that the components you are putting on the shelf meet the operational and technical requirements of the station and are ready when you need them. Components that fail PQI testing can be immediately returned to the supplier for prompt repair or replacement under warranty. Internal Exelon reviews have indicated that the replacement value of these components returned under warranty has been as high as 170 percent of the total PQI program implementation costs for the year. Thus, the PQI program more than pays for itself by ensuring defective components are not put in inventory and would have to be written off later as an expense."

Industry requirements state that "controls are established to monitor supplier performance" and that "performance data and metrics that could have an impact on plant reliability or nuclear safety are trended and promptly communicated back to the supplier to ensure supplier action and continuous improvement." One can imagine the impact when a supplier receives a documented failure test analysis, as compared to the more subjective feedback that is normally provided when there is a failure in the plant or during testing. Overall, suppliers and manufacturers want to provide a quality part. Over the years, the PQI process has demonstrated results by improving parts quality.

Continued

Breaker for dedication, Eaton Navy type: AQB-A103 RMS. An example of a commercial product with high reliability that may be excluded from testing.



A motor control center sample bucket that goes into a motor control center. Having multiple components that make up this assembly and many subcomponents, it may be subject to parts quality testing.

Another example of a breaker for dedication.

Tom Wait, Exelon PowerLabs' operations manager, said, "The more test data you have, the more visibility and clarity you have around trends. The PQI process is the best opportunity we have right now to drive reliability across the industry."

PowerLabs has tested more than 70,000 critical parts for its customers. This provides valuable trending information to not only help identify the parts that will most likely fail (ones that most plants already have sitting on the shelf), but also assist customers as they fine-tune the testing performed to ensure that all known failure modes are tested.

Since the inception of the PQI in 2006, the industry and parts quality have changed. One of the goals of a good parts quality oversight program is to ensure that there is a continuous learning process. That need was certainly evident during the past year and throughout the pandemic.

First and most obviously, the pandemic significantly accelerated the trend toward remote work, with an increase in the number and percentage of virtual meetings and digital collaboration. This new and immediate impact has led to less face-to-face contact oversight and management observations, which flies in the face of methods I have successfully used in the past. During my years at Exelon, I supported numerous supplier performance meetings and always stressed the need to document management and peer observations. The pandemic put a halt to (or at least greatly reduced) those observations without warning or notice, and many suppliers and manufacturers were caught off guard.

A second key new element is the industry's increased focus on single point vulnerability and critical spares to ensure that suppliers and manufacturers understand and are focused on areas that have a direct impact on plant performance. Failure of these components causes latent costs—costs that are buried but still have a great impact on a utility's bottom line. Nuclear energy is becoming a smaller part of many companies' businesses. That translates to fewer staff members who understand the enhanced quality standards and the expectations that should be required. As I like to put it: "Mr. Vendor, we obviously want every part or component order we have with you to be perfect. However, this smaller, select group is what we call 'critical to plant operation,' and we want you to make sure that greater focus and attention is placed on these critical parts. More to the point, we want your 'A team' working on these parts above all others."

A third new objective is to increase the oversight of both fast-tracked projects and expedited critical spare orders or repairs. Supplier resources are limited. Access to experienced management and project managers becomes more difficult with the rise of remote work. In addition, there is a longer lead time for subcomponent parts. All of this adds up to the industry increasing the number of required "run to maintenance" components, which has increased or at least contributed to the need to expedite parts and components. There is a critical need for more frequent and enhanced communication, as well as the establishment of robust and key milestones if they are not already in place.

These three additional focus areas—remote work, single point vulnerabilities, and attention and focus on expedited orders—are some of the significant enhancements that are essential to a strong parts quality process.

The road to improving equipment reliability is a multifaceted path, one that requires planning, the identification of suspect or potentially suspect parts, robust procedures, detailed change management, and above all, leadership to support what must be a station-owned process.

David Mueller is vice president of strategic programs at Paragon Energy Solutions.



For more information on I.C.E. project support contact: **Dennis Morgan - dmorgan@iceservicegroup.com | 412.916.5710**

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INNOVATIONS IN INSTRUMENTATION AND CONTROLS FROM THE TRANSFORMATIONAL CHALLENGE REACTOR PROGRAM

By Sacit Cetiner, Christian Petrie, Venugopal Varma, Nathan See, and Eliott Fountain

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The Transformational Challenge Reactor (TCR) program was launched in 2019 to demonstrate that highly improved, efficient systems can be created rapidly by harnessing the major advances in manufacturing, materials, and computational sciences that have emerged since the end of the first nuclear era. The Department of Energy's Oak Ridge National Laboratory leads the TCR program, which includes contributing partners from other DOE national laboratories and the U.S. nuclear industry. The program leverages some of the nation's leading scientists and engineers and draws from ORNL's lengthy history, institutional knowledge, and capabilities in high-performance computing, materials science development, advanced manufacturing techniques, and nuclear science and engineering.

ORNL initiated the TCR program with the objective of designing, fabricating, and operating a 3D-printed nuclear reactor core by leveraging recent advances in (1) design informed by artificial intelligence, (2) advanced materials derived from additive manufacturing, (3) a digital platform for quality certification of critical components, and (4) integrated sensing and controls to help reduce the cost of operations and maintenance. The program's four technology thrusts were previously covered in depth in *Nuclear News*.[1]

Clearly, the nuclear industry must continue to adapt and innovate to be cost-competitive with other energy production sources. A major reason for the high operation and maintenance costs of today's nuclear power plants is the high staffing levels required to perform routine plant activities to ensure safe and uninterrupted power generation (see Fig. 1). The obvious technological breakthroughs needed to tackle this human-intensive operational paradigm and break the impasse are those that can deliver significantly enhanced automation capabilities. In this technological era in which self-driving capabilities in personal vehicles have essentially become just an ordinary feature, we must deliver the needed technological advances, develop consensus standards to deploy these technologies in a safe manner, and author comprehensive rules and regulatory guidance for licensing and oversight if we are serious about ensuring the future of nuclear power generation.

1 K. Terrani, "Accelerating the deployment of advanced nuclear energy systems," *Nuclear News*, April 2020.

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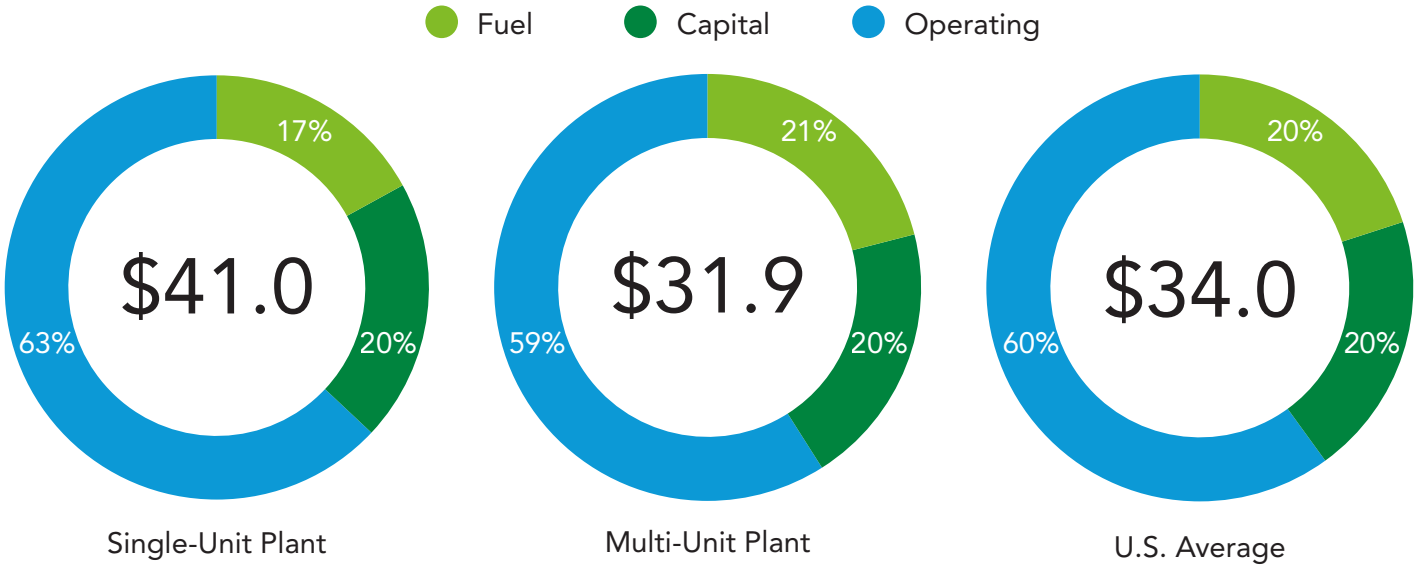

Fig. 1. Breakdown of major contributors to total generating cost (per MWh) for nuclear facilities.[2]

Traditionally, instrumentation and control (I&C) systems are considered the first line of defense in our codes and regulations to protect against unmitigated accidents. For instance, Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, *Domestic Licensing of Production and Utilization Facilities*, makes extensive references to the safety role of the I&C systems. Considering the layering of our established defense-in-depth strategy, this is natural because of the unique functions I&C systems are tasked with, including protecting against anticipated operational occurrences, anticipated transient without scram incidents, and design-basis accidents.

The TCR program identified I&C as a technology thrust to make transformative contributions. To minimize risk from adopting novel technologies, the I&C area at the high level was broken into two major categories: (1) systems related to reactor protection and controls and (2) auxiliary systems. At the top level, all systems, subsystems, and components involved in executing protection or control functions, called "essential I&C functions," are implemented following the established nuclear industry approaches and endorsed regulatory positions. All innovations pursued under the program are considered part of the auxiliary systems and are electrically separated from the systems that provide essential functions. The reactor protection system design was executed following the interim staff guidance to Chapter 7 of NUREG-1537[3] for research and test reactors. This approach allows the pursuit and incorporation of innovative technologies without creating an undue risk to the program's cost and schedule or without causing an unanticipated challenge to fully meet the mission objectives. Nevertheless, the approach enables maturation and demonstration of technologies for the use case under realistic operational conditions.

The driving design principle for the TCR I&C system is simplicity. Within the TCR's agile design iteration approach, I&C is considered integral to the overall systems engineering process, whereas traditionally, it is typically the last system to be designed. This is important and somewhat unorthodox to the conventional ways of invoking the I&C services in the life cycle of a reactor design. For example, very rarely can direct measurements be taken of processes that we want to quantify. Rather, we sample (both spatially and in time) a small fraction of the process and then make correlations to the actual quantity of interest through inferences using—sometimes complex—models and filters.

For instance, temperatures in a flow stream in nuclear power plants are typically measured using thermocouples or resistance temperature detectors embedded into a

2 Nuclear Energy Institute, White Paper, "Nuclear Costs in Context" (2016 data).

3 "Interim Staff Guidance Augmenting NUREG-1537, Part 2, 'Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Standard Review Plan and Acceptance Criteria,' for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors," October 17, 2012, ADAMS Accession No. ML12156A075.

thermowell. This structure penetrates about a quarter of the way into the flow field, indicating predominantly the temperature around the tip of the probe. The assumption here is that the flow is generally stable, and any dynamic lags (mostly associated with the heat transfer) are properly addressed in the feedback loop. However, under certain conditions, it has been demonstrated—and painfully experienced—that this may not always be the case.[4] The flow field is usually in a quasi-equilibrium at best, and phenomena exist that cause instabilities, resulting in large oscillatory behavior. Once the design is finalized, all these anomalies must then be addressed as part of a large measurement uncertainty that results in gross operational inefficiencies. These uncertainties can sometimes become excessive and may require design modifications at a significant cost. The TCR program aims to overcome this limitation by considering sensor types and locations early in the design process.

In this article, we present a snapshot of innovative research and development activities that can be of interest to the nuclear science and engineering community at large. The products and processes generated through these activities within the TCR program may be particularly relevant to various microreactor designs pursued in the United States.

The research and development part of the TCR I&C activities can be summarized in three focus areas:

1. Instrumentation-informed design iterations.
2. Embedded sensing.
3. Reactivity control systems.

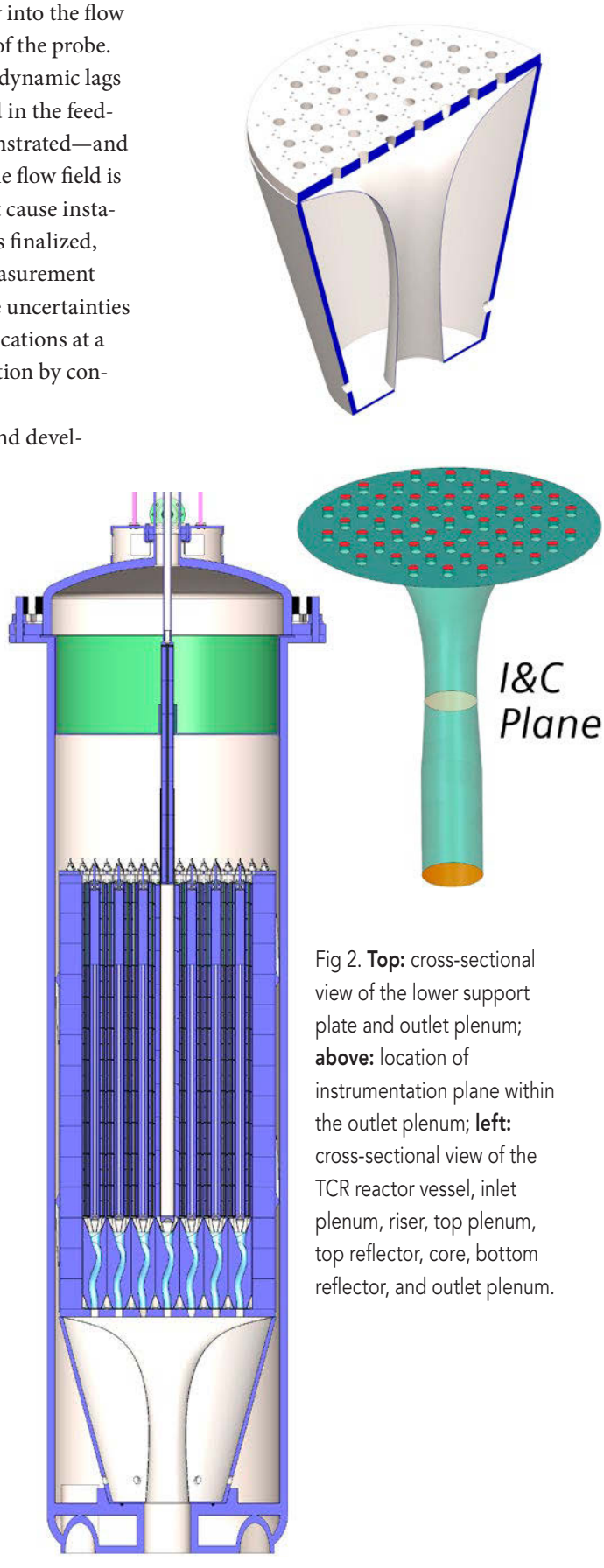

Fig 2. **Top:** cross-sectional view of the lower support plate and outlet plenum; **above:** location of instrumentation plane within the outlet plenum; **left:** cross-sectional view of the TCR reactor vessel, inlet plenum, riser, top plenum, top reflector, core, bottom reflector, and outlet plenum.

I&C AS AN INTEGRAL ELEMENT OF DESIGN ITERATION

An example of the tight iterative process between the core design and instrumentation placement is the optimization of the core outlet plenum geometry (Fig. 2). The large uncertainties in the temperature at the outlet of the core necessitated a change in the design in the outlet of the core. Specifically, through this study, temperature variations were able to be significantly reduced across the instrumentation plane, thus minimizing the uncertainty in the measurement caused by unstable flow fields. This instability is an inevitable result of uneven heating of the coolant as it flows through multiple parallel core channels and enters the outlet plenum. Improper mixing and placement of temperature sensors can lead to large uncertainties and possibly unconservative outputs.

To reduce time lag in temperature sensing, placing

4 H. M. Hashemian, *Maintenance of Process Instrumentation in Nuclear Power Plants*, Springer, Berlin (2006). Please refer to Section 6.3.9, "Effect of Temperature Stratification."

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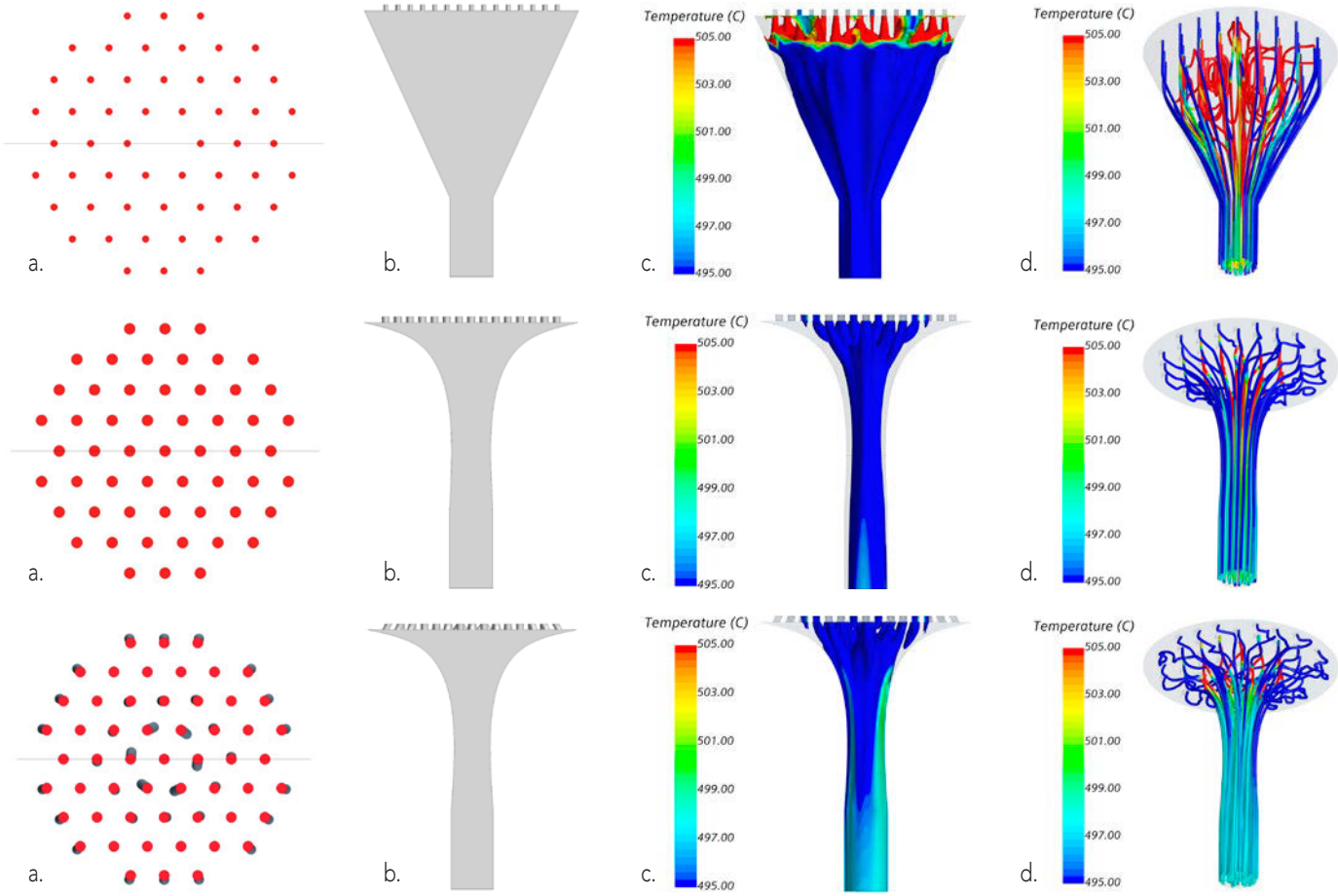


Fig. 3. Original design (top), initial study design (middle), and optimized design (bottom): (a) direction of inlet nozzles, (b) outer shell and cross-sectional view of inlet nozzles, (c) multi-range isosurface of acceptable average temperature margins, (d) stream tubes of acceptable average temperature margins.

the core exit thermocouples closer to the core outlet is logical. As an initial decision, these thermocouples were placed about midway into the outlet plenum. The original lower support plate and outlet plenum designs (Fig. 3, top) resulted in a temperature variation of 49°C across the instrument plane. This led to a series of design studies to further reduce the temperature variation. Using a constrained single-objective optimization scheme, we were able to optimize the shapes of the lower support plate and the outlet plenum. The optimization domain searched for favorable geometric modifications that led to temperature variations of less than ±5°C while constraining the pressure drop to less than 3.5 kPa. The shape optimization process included parameterization of (1) the angular direction of the individual channel nozzles that redirect the core flow into the outlet plenum (see Fig. 3a) and (2) the surface profile of the outlet plenum outer shell (as a spline function, see Fig. 3b). The simulation was performed using a Reynolds-averaged Navier-Stokes computational fluid dynamics model. The optimization process generated 150 initial design variations with 24 of them being feasible.

Figure 3 shows results for the original design (top), the initial parameterized design (middle), and the optimized design (bottom). Figure 3a clearly shows that the optimal design evolves to incorporate individual flow nozzles that lead to robust mixing by redirecting the flows from the inner rings to the periphery, while redirecting the flows from the outer rings into the center. Additionally, the spline optimization evolves to a slightly slimmer shell design for the outlet plenum, which results in minor acceleration of the flow as it exits the plenum. The optimal design (Fig. 3, bottom) leads to a standard deviation of ~1°C while maintaining the desired maximum pressure drop of 3.5 kPa. Table 1 summarizes this remarkable reduction in temperature variation. Details on this study can be found in the literature.[5]

Although fabricating these initial components with

5 N. D. See et al., "Design Optimization of the Transformational Challenge Reactor Outlet Plenum," article submitted for publication in *Nuclear Science and Engineering*.

	Temperature variation (°C)	Standard deviation of temperature on instrumentation plane (°C)	Pressure drop (kPa)
Original design	**48.9**	**10.5**	**12.3**
Initial study design	**23.8**	**5.0**	**1.8**
Optimized design	**8.4**	**1.2**	**3.4**

Table 1. Design results.

optimized flow channels is most likely attainable with subtractive manufacturing techniques, additive manufacturing offers more geometric complexity that could be leveraged to further enhance mixing and/or reduce the pressure drop in future studies. The result is smaller uncertainty on the temperature readings with the added benefit of a smaller pressure drop across the flow channels.

EMBEDDED SENSING

One approach to reducing operation and maintenance costs is to design components and systems that are capable of reporting their health conditions through self-monitoring and self-diagnostics capabilities. If these features are integrated properly into system operations, these data streams can be used to make informed decisions about optimal operational strategies and maintenance scheduling and provide highly accurate manufacturing or production forecasts. Obviously, one of the foundational technologies that enables these capabilities is ubiquitous sensing, which generates and transmits large quantities of data about the processes and the condition of components.

Conventionally, measurements in nuclear reactors and power plants in general involve a limited number of sensors. Embedded sensing is an emerging concept that enables probing directly into structures for key quantities of interest. Online monitoring of critical structures, systems, and components beyond scarce, pointwise, and low-sampling-rate measurements offers the potential to significantly boost the data density and will inevitably lead to more informed operational decision-making capabilities through enhanced diagnostics and prognostics. Additionally, new fabrication options afforded by additive manufacturing unleash opportunities that did not exist before, such as fabrication with tortuous embedment channels or co-fabrication directly with sensors. These innovations have the potential to bring about a new paradigm for in-service inspection because they provide insights from within internal structures.

Fig. 4. Four embedded sensors in a 3D-printed silicon carbide structure.

Additive manufacturing technologies allow for sensors to be located or even embedded within nuclear components during the manufacturing process at locations that would be extremely challenging, if not impossible, to access using traditional manufacturing processes. For example, in a traditional nuclear power plant, the hottest location within the core is at the centerline of the uranium dioxide pellets that are contained inside zirconium alloy cladding. Due to the difficulty in drilling holes in brittle, uranium-bearing ceramics, measurements of fuel centerline temperatures are not made directly during reactor operation and can only be estimated based on thermal models and limited fuel performance tests that are conducted in research reactors before commercial reactor operation. This leads to significant conservatism when establishing the allowable operating envelope for the fuel, and it can also limit options for fuel loading based on expected power peaking. The ability to monitor local distributions

Continued

of fuel temperature and reactor power could greatly reduce conservatisms and allow for increased operational flexibility.

ORNL has developed, demonstrated, and patented a novel additive manufacturing process that allows for 3D printing of complex silicon carbide ceramic fuel structures within which a wide range of nuclear materials can be embedded, including fuel, neutron moderators, absorbers, and (more recently) sensors.[6] Therefore, in addition to optimizing the core for neutronic and thermal performance, these structures can be integrated with sensors to directly monitor fuel temperatures and neutron flux at the most critical locations. One example of sensors embedded within a complex 3D-printed silicon carbide structure is shown in Fig. 4. Furthermore, incorporating advanced sensing technologies such as fiber optic sensors offers the ability to perform spatially distributed measurements. With these sensors, operators now have access to not only the fuel temperature at a few discrete locations but also the entire distribution of temperatures within each instrumented fuel can.

In addition to monitoring fuel temperature and neutron flux, the ability to print complex metal structures with integrated distributed sensing could also improve knowledge of coolant flow through the many complex parallel flow channels within the core and how those individual channels mix at the outlet of the core. Mixing of individual flow channels at the core outlet has historically been a challenge for many high-temperature gas-cooled reactor concepts. As described in the previous section, TCR is taking advantage of modern modeling and simulation tools to optimize complex, 3D-printed flow structures that encourage mixing of the various flow channels, directing the flow to a common outlet where the well-mixed coolant can be reliably recorded using traditional instrumentation.

Also, the ability to embed spatially distributed fiber optic temperature sensors within the 3D-printed flow structures allows for local measurements of the individual core outlet temperatures before mixing. With this approach, if the channel flow is obstructed, or if there are local variations in power, the distributed sensors can detect these issues and determine where the anomaly may be occurring.

6 C. M. Petrie et al., "Embedded Sensors in Additively Manufactured Silicon Carbide," *Journal of Nuclear Materials*, vol. 552, 153012 (2021); https://doi.org/10.1016/j.jnucmat.2021.153012.

REACTIVITY CONTROL

Reactivity control is a mature engineering field. Because the TCR design uses high-temperature, high-pressure helium as the working fluid, any penetration of the primary boundary would require using dynamic seals for moving surfaces to significantly reduce leakage. The program reached out to leading vendors of shutdown and fine-motion control rod drive mechanisms. It became clear that implementing this path would result in a substantial delay at a significant engineering cost.

The TCR design's accelerated timeline forced the design team to come up with creative solutions. Because the key challenge came from penetration of the primary boundary, the team investigated the design options that allowed operation of actuation devices externally.

Two types of reactivity control systems are being developed under the TCR program: (1) a central shutdown rod system, which is a safety class–independent reactivity protection system to rapidly terminate criticality, and (2) external fine-motion shroud control drive mechanisms. Only the central shutdown rod system is described in this article.

Classical design of a shutdown mechanism uses gravity, springs, or pressurized gas to quickly release black rod banks into the reactor core to stop the nuclear reaction, which requires penetrations into the reactor vessel and the use of seals for such a system to operate. If the shutdown rod can be operated without the need for a penetration into the pressurized vessel, the design and control become that much simpler. This simplifies the design of the protection system and is the motivation behind the TCR central shutdown rod design.

Electromagnets are commonly used to generate the force to maintain the black rod banks above the core. The release mechanism relies on de-energizing the electromagnets and the subsequent loss of holding force and free fall of rod banks.

Typically, electromagnets are located inside the reactor pressure vessel. For the TCR central shutdown rod, the idea is to locate the electromagnet outside the pressure vessel (Fig. 5). Once latched, the axial position of the electromagnet is also the position of the shutdown rod. The electromagnet's elevation can be precisely controlled using a leadscrew within 0.05-mm accuracy. The shutdown rod is housed within a standpipe on the top of the TCR vessel head, and an annular electromagnet is positioned around the outside of the standpipe. When the electromagnet is de-energized, the shutdown rod is released and falls into

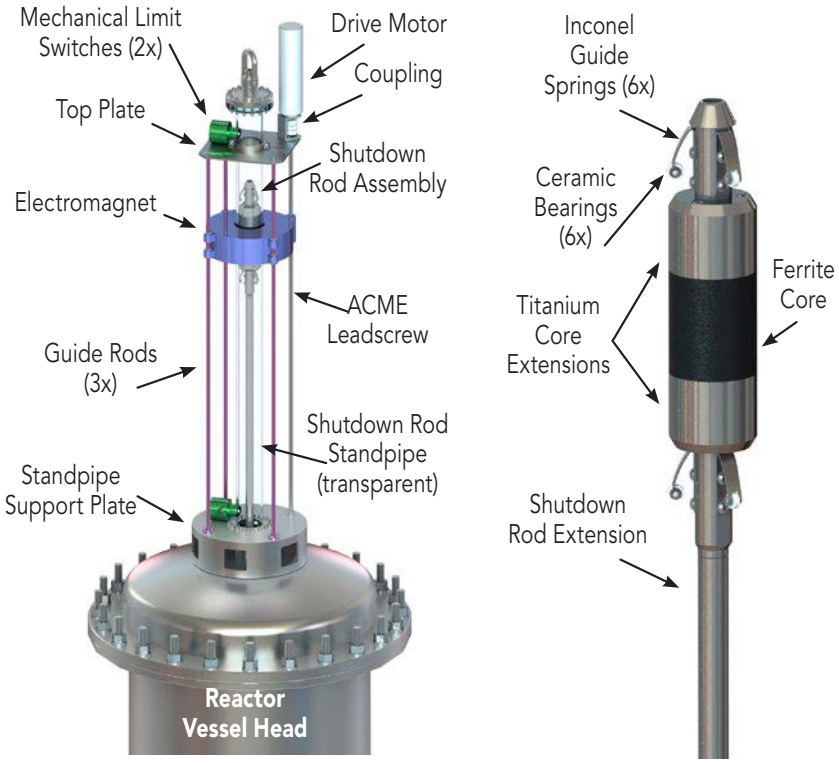


Fig. 5. Shutdown control rod actuation mechanism.

the reactor core by gravity. The electromagnet is designed to perform at the highest anticipated design temperature above the reactor vessel and is sized to generate a holding force two times the weight of the rod at the design conditions.

The standpipe is attached to the reactor vessel head and extends above the core to accommodate the retracted length of the shutdown rod. The standpipe also houses two limit switches that sense and limit the range of motion of the rod to its fully retracted and fully inserted locations.

The shutdown rod is made of a neutron absorber material and titanium core extensions that sandwich the ferrite core and interface with the limit switches. The ferrite core is optimized for maximum magnetic force and minimal weight. The guide springs and ceramic bearings center the shutdown rod in the standpipe even when the temperature rises to 500°C. Chamfers on the titanium extensions act as places for the limit switches to engage at the top and bottom end of travel of the control rod. The mechanical roller limit switches are also rated for 500°C.

The ferrite core can be made from highly permeable materials such as cast iron, SAE 1010 steel, SAE 1006 steel, or Permendur. When the electromagnet is powered and placed in alignment with the ferrite core, the magnetic field from the electromagnet passes through the ferrite core and holds the shutdown rod in position in plane with the magnet. Most of the field lines pass through the outer material of the ferrite core, making it possible for the core to be mostly hollow yet create a large holding force. The holding force generated by the external magnet was measured to be approximately double the weight of the shutdown rod assembly in the initial testing.

A motor connected to a leadscrew mechanism is used for positioning the electromagnet along the standpipe. The selected motor is radiation hardened and can operate at an ambient temperature of 175°C and can be air-cooled if needed. In the event of loss of power to the electromagnet, the magnetic force vanishes, allowing the rod to fall into the core under gravity. Attaching the shutdown rod to the electromagnet, positioning the rod along the standpipe, and the scram function were successfully demonstrated in the laboratory setting at ORNL.

CONCLUSIONS

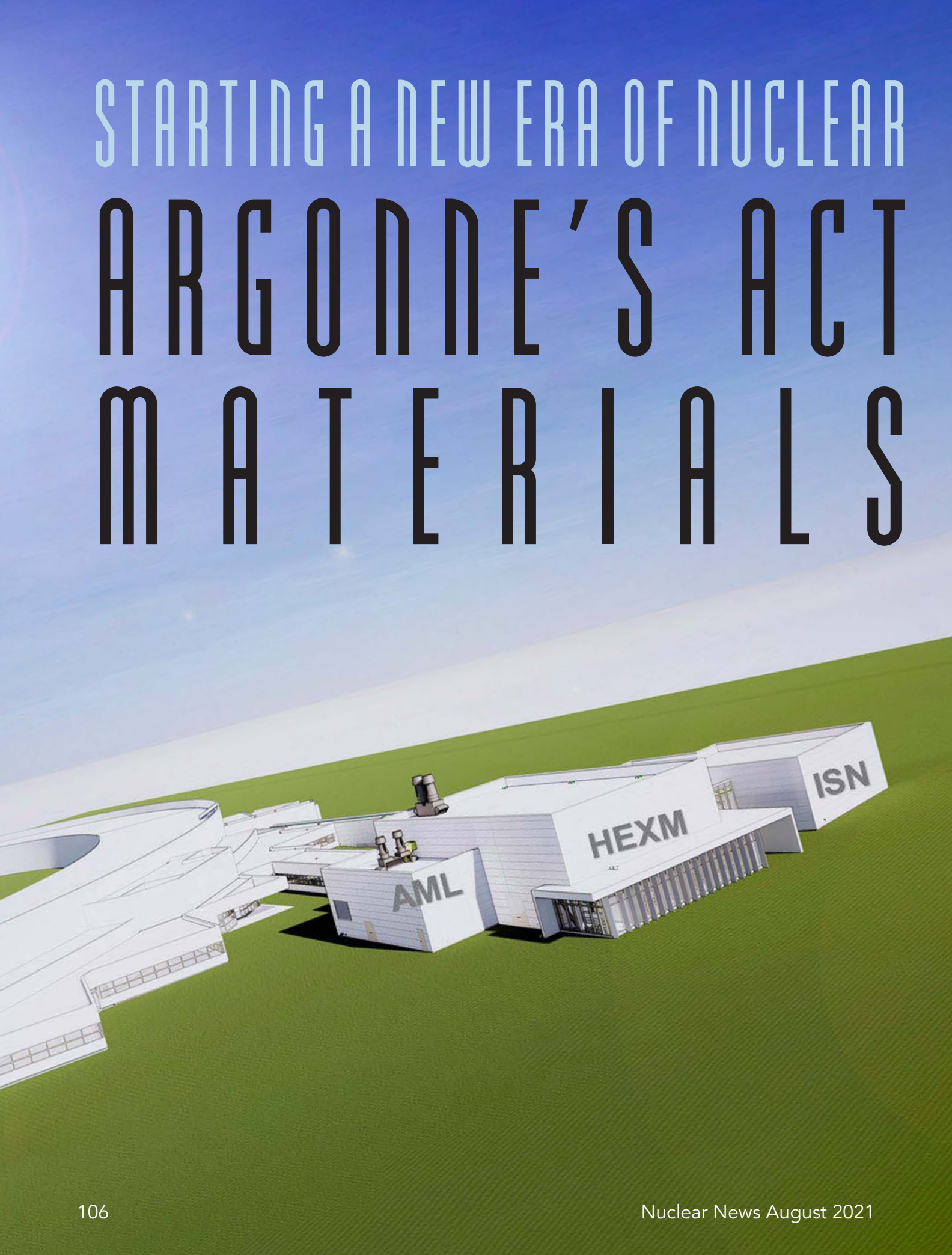
In keeping the I&C design an integral part of the overall core/reactor design process, we demonstrate the potential benefits of an optimized design of the lower support plate and the outlet plenum for a well-correlated temperature measurement. In addition, embedding sensors in critical locations within the fuel and core structure allows for greatly enhanced monitoring. These all reduce the uncertainties, thereby reducing the operating margins while maintaining safe operations. Finally, a novel shutdown rod actuation system, which requires no vessel penetrations and uses a failsafe release mechanism, is being demonstrated and refined at ORNL.

ACKNOWLEDGMENTS

The Transformational Challenge Reactor program operates under the auspices of the U.S. Department of Energy, Office of Nuclear Energy.

STARTING A NEW ERA OF NUCLEAR

ARGONNE'S ACT MATERIALS



INNOVATION WITH IVATED LAB

By Christina Nunez

The lack of a specialized laboratory at Argonne National Laboratory's Advanced Photon Source (APS) has slowed efforts to study irradiated materials at the facility. Things will change soon, however, with the addition of the new Activated Materials Laboratory that is planned to be built and operational by 2024.

A new facility being built at the Advanced Photon Source will allow research into irradiated materials.

This rendering shows the Activated Materials Laboratory (AML), to be constructed as part of the Advanced Photon Source upgrade that includes the High-Energy X-ray Microscope (HEXM) and the In Situ Nanoprobe (ISN). This new facility will simplify the process of researching nuclear materials.

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The APS

The high-energy X-rays at the APS are well-suited to study materials used in reactors, such as steels and uranium fuels. Being able to peer inside these materials and analyze their characteristics is critical to building advanced nuclear reactors.

Argonne has been studying irradiated material at the APS for about 25 years. Any radiological material that comes to the APS must be enclosed in a container that, for safety reasons, cannot be opened on site due to the lack of a facility that can handle it safely. Samples might be as small as a speck of dust, mounted within a capsule and protected by a radiation shield. If a sample gets out of alignment during shipment and needs to be adjusted before imaging, it must be sent out to a radiological lab, causing delays for researchers who have been awarded time at the APS.

"We want to make it more efficient for the nuclear materials community to be able to use these advanced X-ray facilities, while maintaining our strong focus on safety,"

said Argonne materials scientist Meimei Li.

"Having the Activated Materials Lab adjacent to one of the world's most powerful X-ray facilities is a unique capability that fulfills a strong need."

Continued

The Advanced Photon Source, one of the brightest sources of X-rays in the Western Hemisphere. Photons are accelerated to over 99 percent of the speed of light around its ring, which is the size of a baseball stadium. (Image: Argonne National Laboratory)

The Activated Materials Laboratory, shown under construction here, will have equipment for scientists to safely open radioactive samples and work with them as needed. (Image: Argonne National Laboratory)

The AML

The Activated Materials Lab will have equipment allowing scientists to safely open samples and work with them as needed. The equipment includes glove boxes and fume hoods with local shielding to protect researchers as they handle samples. The lab will be part of the Long Beamline Building now under construction as part of a larger upgrade to the APS. That building will house the High-Energy X-ray Microscope (HEXM), which is designed to use X-rays that penetrate thicker materials of various sizes and is well-suited for the dense and complex materials often studied by nuclear scientists.

Researchers will be able to manipulate their samples within the Activated Materials Lab before using the HEXM or any of the dozens of beamlines available at the APS. In addition to allowing for these sample adjustments, the Activated Materials Lab will be a central location housing the equipment needed to study irradiated materials in real-life conditions—for example, to gauge the additional effects of temperature or pressure changes on a material's internal structure.

The In Situ Nanoprobe (ISN) is a 250-meter (820-foot) beamline specifically designed for tightly focused *in situ* imaging. Its beam can focus down to 20 nanometers, and it provides enough space between the optics and the sample to change the environment of the sample (through temperature, pressure, and other methods) and track the effect of these changes at extremely fine resolution. One application of the ISN would be more precise understanding of electrochemical reactions inside batteries, which is anticipated to lead to breakthroughs in extending battery life.

The Work

Scientists from universities, industry, and research laboratories must apply for time at the APS, which runs for three months at a time with a one-month shutdown between runs. Beam time allocation is highly competitive, with limited time per experiment, so researchers want to be able to maximize their time conducting X-ray experiments rather than using it to get their samples ready.

"Today, if a sample needs to be moved, nothing can be done in less than a few hours, at a minimum," said Argonne physicist Jonathan Almer, who works with the high-energy X-rays that will be the HEXM's specialty. "Sometimes it may take days, particularly if the need falls on a weekend. Since beam time is such a precious resource, any offline activity that we can make more efficient is a positive."

The Activated Materials Lab is being funded by the Nuclear Science User Facilities (NSUF) program in the Department of Energy's Office of Nuclear Energy. By streamlining the research process and boosting Argonne's ability to accommodate radiological samples, the Activated Materials Lab potentially will expand the range of materials researchers can explore at the APS.

"The NSUF has the largest library of activated materials in the nation," Almer said. "It has many orders of magnitude more material available than we have been able to study in the past. This facility will enable new science that can help extend the lifetime of our existing nuclear facilities and pave the way for next-generation reactors."

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Duke files SLR application for Oconee

Duke Energy has filed a subsequent license renewal (SLR) application with the Nuclear Regulatory Commission for the Oconee nuclear plant reactors, the Charlotte, N.C.–based utility announced on June 21.

Located on Lake Keowee in Seneca, S.C., Oconee is Duke's largest nuclear plant, housing three pressurized water reactors: the 847-MWe Unit 1, 848-MWe Unit 2, and 859-MWe Unit 3. Currently, Oconee-1 is licensed to operate through February 6, 2033; Oconee-2 through October 26, 2033; and Unit 3 through July 19, 2034. Subsequent, or second, license renewals would extend those licenses to 2053 and 2054.

"Oconee Nuclear Station has provided safe, reliable, carbon-free energy to customers and our communities for nearly 50 years," said Steve Snider, Oconee's site vice president. "Renewing these operating licenses is a significant step toward achieving Duke Energy's aggressive carbon-reduction goals, which cannot be achieved without nuclear power."

Duke's chief nuclear officer, Kelvin Henderson, commented: "Our nuclear stations remain economic drivers for their communities, providing thousands of well-paying jobs, significant tax revenues, partnership opportunities, and other benefits."

In September 2019, Duke announced its intent to seek SLRs for its entire nuclear fleet of 11 reactors, with Oconee scheduled to be the first. Initial license renewals have already been approved for the fleet, enabling all units to operate for 20 years beyond the expiration of their original 40-year licenses. SLRs would add 20 more years of operation, permitting each reactor to operate for a total of 80 years.

SLR applications are expected to follow for Brunswick-1 and -2, in Southport, N.C.; Catawba-1 and -2, in York, S.C.; Harris, in New Hill, N.C.; McGuire-1 and -2, in Huntersville, N.C.; and Robinson, in Hartsville, S.C. Robinson, the oldest reactor in the fleet, could operate until 2050 if its application is approved, while Harris, the last Duke reactor to begin commercial operation, could be licensed to operate into 2066.

Above: Aerial view of Oconee Nuclear Station. (Photo: Duke Energy)

ADVANCED REACTORS

Oklo awarded $2 million to commercialize fuel recycling

California-based Oklo has received a $2 million cost-share award from the Department of Energy for the commercialization of advanced fuel recycling capabilities by using electrorefining technology. Oklo is matching $1 million in funds and is partnering with the DOE and Argonne National Laboratory on this public-private partnership, which is intended to help reduce fuel costs for advanced reactor designs while reducing waste by turning used fuel into advanced reactor fuel.

The project is being supported by the DOE's Technology Commercialization Fund, a nearly $30 million funding opportunity that leverages the research and development funding in the department's applied energy programs to mature promising energy technologies with the potential for high impact.

"We are proud to be selected to accelerate the commercialization of advanced fuel recycling and development and bring clean power to market quickly and cost-effectively," said Caroline Cochran, cofounder and chief operating officer of Oklo. "When your fuel is millions of times more energy-dense than alternatives, that's a key enabler to deliver the cheapest forms of clean power available to humanity."

An artist's rendition of Oklo's Aurora powerhouse. (Image: Gensler)

Oklo's 1.5-MWe fast spectrum design known as Aurora is the first advanced non-light-water reactor to be accepted for a licensing review by the Nuclear Regulatory Commission. The company has also received a site use permit from the DOE, demonstrated fabrication of its fuel, and gained access to recovered used fuel from Idaho National Laboratory.

VOGTLE

Special inspection begins at Unit 3

The Nuclear Regulatory Commission in June launched a special inspection at the Vogtle new-build site to identify the errors that necessitated construction remediation work on Unit 3's electrical cable raceway system.

A cable raceway system consists primarily of conduits and cable trays designed to route and support the cables needed to ensure that safety-related equipment is powered to perform its safety functions, according to a June 21 NRC press release.

The NRC's inspection team will review Southern Nuclear Operating Company's actions "following the discovery that led to construction

Power & Operations continues

Vogtle's Unit 3, in June. (Photo: Georgia Power)

remediation work, including a review of [the company's] root cause investigation, corrective actions, construction quality assurance process, and any potential implications for Unit 4," the NRC stated. A public report documenting the team's findings and conclusions is to be issued within 45 days of the end of the review.

In April 20 testimony submitted to the Georgia Public Service Commission, Southern Nuclear's Stephen Kuczynski and Aaron Abramovitz stated, "As the project team worked to close out work packages during system turnover and during the preparation for testing, our ongoing reviews and inspection processes identified instances of cables connected to control system equipment not being properly spaced, a variety of nonconforming conditions regarding cable terminations, some cables pulled too tight so that they did not lie in the cable tray as designed, and some cables as installed in cable trays not meeting design standards."

The Southern Nuclear officials also said that the remediation work caused a delay to the start of the unit's hot functional testing, which resulted in the decision to push back the expected commercial operation date of Vogtle-3 to December of this year—a date that was later pushed back further, to January 2022.

UAE

EDF and ENEC partner on nuclear R&D

Électricité de France has signed a letter of intent with the Emirates Nuclear Energy Corporation to develop a memorandum of understanding for cooperation on research and development in the nuclear energy sector.

According to a June 30 press release, the collaboration is the latest example of ENEC's commitment to advancing the United Arab Emirates' nuclear energy industry, supporting innovation and clean electricity production, and tackling climate change.

Laurent Clement, EDF Middle East chief executive officer (seated, left), and Ahmed Al Mazrouei, ENEC vice president of R&D (seated, right), sign a letter of intent on June 30 to cooperate on nuclear R&D. Looking on are Hervé Maillart, head coordinator of the French nuclear industry at EDF (left), and ENEC CEO Mohamed Al Hammadi. (Photo: ENEC)

"The planned MOU," the release stated, "will elevate the strategic partnership between the two entities through sharing global expertise and the latest advancements in the nuclear energy sector, as well as exploring the production of green hydrogen powered by carbon-free nuclear energy."

The signing took place at the 2021 E-FUSION (Emirati-French Industrial Supply Chain Initiative for Nuclear) event in Dubai—an annual, two-day confab launched by ENEC, EDF, and GIFEN (an association for the French nuclear industry) in 2019 to develop new Franco-Emirati commercial relations in the nuclear sector.

Speaking at the event on June 29, ENEC's chief executive officer, Mohamed Al Hammadi, said, "Together, we are working to harness the expertise of the French nuclear industry to develop our national nuclear industry. Strategically speaking, this is a crucial time for the UAE's nuclear energy program. Unit 1 at Barakah is now commercially operational, while Unit 2 is scheduled to be operational in a few months, and Units 3 and 4 are set to come on line in a couple of years. France has enjoyed great success in being a global leader in the field of clean nuclear energy, and we look forward to working with them in developing our safe and clean energy goals."

INDIA

Unit 5 construction begins at Kudankulam

Work on the third phase of the multi-reactor project at India's Kudankulam nuclear power plant formally commenced June 29 with the first pouring of concrete into the foundation plate of the Unit 5 reactor building.

The project's third phase comprises the construction of Units 5 and 6—both VVER-1000 model AES-92 pressurized water reactors supplied by Rosatom, Russia's state-owned atomic energy corporation. According to Rosatom, preliminary work already completed at Unit 5 includes the concrete bedding for the foundations of the reactor building, the auxiliary reactor building, and the turbine and power supply buildings.

Power & Operations continues

India's Kudankulam plant, during the June 29 Unit 5 construction launch ceremony. (Photo: Rosatom)

"For many years, the Kudankulam nuclear power plant construction project has been a symbol of close cooperation between Russia and India," said Alexey Likhachev, Rosatom's director general, during a virtual ceremony marking Unit 5's construction start. "However, we do not want to stop at what has already been achieved. Rosatom has all the most advanced nuclear power technologies. Together with our Indian colleagues, we are ready to launch the serial construction of the state-of-the-art Generation III+ Russian-designed nuclear power units at a new site in India."

(In October 2018, the two nations signed a pact to build six reactors at a site in India not yet selected.)

Others attending the construction launch event included Kamlesh Nilkanth Vyas, chairman of India's Atomic Energy Commission and secretary of its Department of Atomic Energy, and Satish Kumar Sharma, chairman and managing director of Nuclear Power Corporation of India Limited (NPCIL), operator of Kudankulam.

The initial phase of the Kudankulam project was completed in March 2017 with the commercial start of Unit 2, Unit 1 having entered operation in December 2014. The project's second phase, the construction of Units 3 and 4, began in June 2017, with the first pour of concrete for Unit 3's reactor foundations. Currently, Units 3 and 4 are about 50 percent complete, according to NPCIL. Units 5 and 6 are scheduled for completion in 66 and 75 months, respectively.

ROMANIA

Cernavoda deal ratified with U.S.

Romania has ratified a draft intergovernmental agreement signed in 2020 with the United States on cooperation in the field of nuclear energy. Initialed last October by Romania's energy minister, Virgil Popescu, and the then U.S. energy secretary Dan Brouillette, the agreement, reportedly worth some $8 billion, calls for cooperation on completing the construction of Units 3 and 4 at Romania's Cernavoda nuclear power plant, as well as the refurbishment of Unit 1. The European Commission gave its nod to the agreement last November.

The deal was ratified by the Romanian Senate on June 22 by a vote of 129 to 1 (with two abstentions). At this writing, it has been sent to the desk of Romanian president Klaus Iohannis for approval.

Completion of the proposed Cernavoda projects would result in significant carbon dioxide emission reductions—from 10 million tons of CO_2 avoided each year to 20 million tons avoided after 2031, according to a June 23 press

The Cernavoda plant, in southeastern Romania. (Photo: Wikimedia Commons/ Zlatko Krastev)

release from Nuclearelectrica, the state-owned Romanian utility that operates Cernavoda. The projects would also contribute to the development of the internal supply chain, generate up to an additional 9,000 jobs, and stimulate research, innovation, and development in the nuclear industry, Nuclearelectrica said.

Romania's sole nuclear power facility, Cernavoda consists of two operating 650-MWe CANDU-6 pressurized heavy water reactors, Units 1 and 2, plus the partially completed Units 3 and 4, also CANDU-6 reactors, work on which was halted not long after the collapse of the Ceausescu regime in 1989.

POLICY

Legislation introduced to extend production tax credits to nuclear

Pascrell

Companion bills that call for amending the Internal Revenue Code to establish a tax credit to help existing merchant nuclear plants continue operations debuted on Capitol Hill in June.

In the House on June 21, Rep. Bill Pascrell (D., N.J.) introduced the bipartisan H.R. 4024, dubbed the Zero-Emission Nuclear Power Production Credit Act of 2021. Cosponsors of the legislation include Reps. Brian Fitzpatrick (R., Pa.), Tom Suozzi (D., N.Y.), John Katko (R., N.Y.), Danny Davis (D., Ill.), Anthony Brown (D., Md.), Dutch Ruppersberger (D., Md.), Cheri Bustos (D., Ill.), Mike Doyle (D., Pa.), and Bobby Rush (D., Ill.).

Power & Operations continues


Cardin

And on June 24, Sen. Ben Cardin (D., Md.) introduced the Senate's version, S. 2291, with Sens. Joe Manchin (D., W.Va.), Tom Carper (D., Del.), Sheldon Whitehouse (D., R.I.), and Cory Booker (D., N.J.) joining as cosponsors.

The legislation would make existing merchant nuclear plant owners/operators eligible for the same 1.5 cent/kilowatt-hour ($15/megawatt-hour) credit already available to wind operators, a press release from Cardin's office stated.

Current tax law provides a production tax credit for eligible nuclear power facilities only during the first eight years of operations. There is no tax credit for older nuclear plants. The proposed credit, according to the release, would be phased out if market revenues reach 2.5 cents/kilowatt-hour ($25/megawatt-hour), if greenhouse gas emissions drop 50 percent from 2020 levels, or after 10 years.

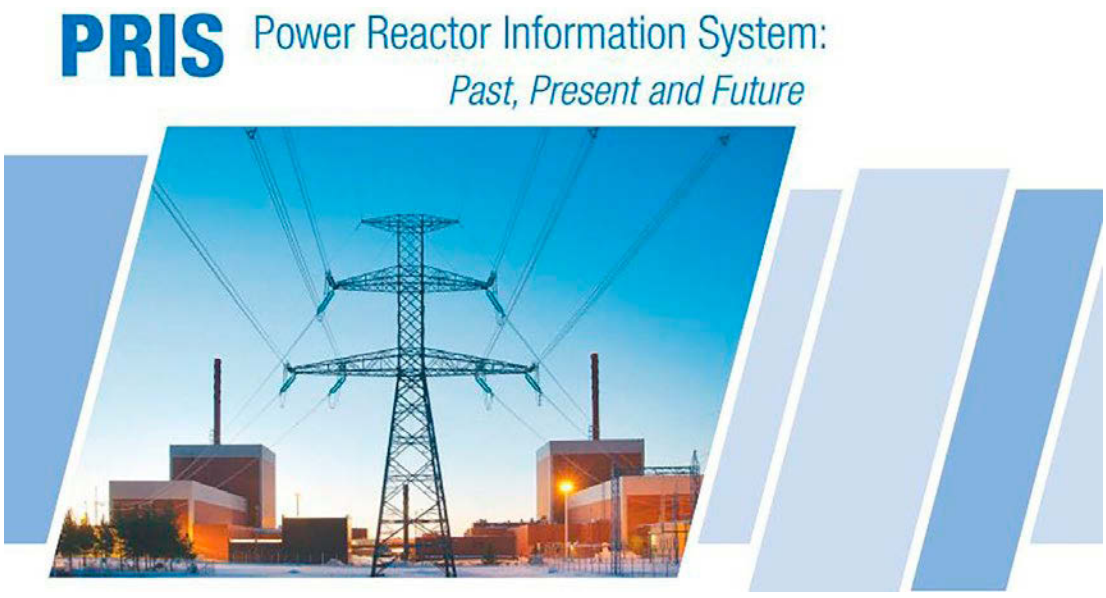
"Our bipartisan legislation to combat climate change will allow existing nuclear plants to continue producing the clean, zero-emission energy that our nation needs while supporting thousands of jobs in New Jersey," Pascrell said. "The Biden administration has made clear that our nation's nuclear infrastructure is essential to meeting our climate goals. Legislation like this will benefit millions today and billions tomorrow, and I look forward to working with my colleagues toward its passage in the House."

Cardin commented, "America needs to reduce our reliance on fossil fuels, so it is imperative that we keep these reactors operating safely while we continue to work on demand reduction, renewables, energy storage, and transmission grid resiliency. Reducing air pollution and dangerous greenhouse gas pollution is good for the environment, public health, and our economic and our national security."

IAEA

Global nuclear power status data for 2020 released

The International Atomic Energy Agency in June released its annual nuclear power status data, collected by the Power Reactor Information System (PRIS), the agency's publicly available nuclear power database.



According to the IAEA's data summary, nuclear power in 2020 played an important role as an adaptable and reliable supplier of electricity during the pandemic.

"Restrictions on economic and social activity during the COVID-19 outbreak in 2020 led to an unprecedented and sustained decline in demand for electricity in many countries, at 10 percent or more, compared to 2019 levels," the summary stated. "This created challenges for both electricity generators and system operators. Low-carbon electricity prevailed with the

increasing contribution of renewable electricity, and nuclear power generation proved to be resilient, reliable, and adaptable. The flexibility of nuclear power demonstrated how it can support the clean energy transition."

Among the summary's 2020 data points are the following:

- Global operating nuclear power capacity was 392.6 GWe from 442 operational reactors in 32 countries.
- Overall, nuclear capacity since 2011 has gradually increased, including some 23.7 GWe added by the connection of new units to the grid and upgrades to existing reactors.
- Nuclear power reactors supplied 2,553.2 TWh of low-emission and dispatchable electricity, accounting for about 10 percent of total global electricity generation and almost one-third of the world's low-carbon electricity generation.
- Nuclear power production was slightly lower compared to 2019's 2,657.1 TWh. Since 2012, however, there has been an increase of more than 8 percent.
- Five new pressurized water reactors with 5.5 GWe of nuclear capacity were connected to the grid.
- Over 44 percent of new capacity, equating to more than 2.4 GWe, was added by two countries with no previous nuclear power operating experience: Belarusian-1 (1,110 MWe) in Belarus and Barakah-1 (1,345 MWe) in the United Arab Emirates.
- At the end of the year, 52 reactors with over 54.4 GWe of capacity were under construction in 19 countries, including in two countries building their first power reactors.
- The global median capacity factor was 84.6 percent, in line with the load factor in recent years.

Power & Operations continues

CANADA

Feasibility study for nuclear hydrogen underway

The Nuclear Innovation Institute (NII) has launched a study on the role of nuclear power in supporting a growing hydrogen economy. The study will be the first of its kind in Canada to evaluate the technical viability and business case for hydrogen production from nuclear power, according to NII, an Ontario, Canada–based nonprofit formed in 2018 to accelerate innovation in the nuclear industry.

Work on the study is being led by Arcadis, a global design and consultancy organization headquartered in the Netherlands, with support from NII and project partners Bruce Power and Greenfield Global.

"Hydrogen is poised to play a key role in a net-zero future," said David Campbell, director of the Bruce Power Centre for Next Generation Nuclear. "This project will provide a unique exploration of how nuclear power can provide the clean, affordable hydrogen that Ontario will need to continue decarbonizing our economy."

The Centre for Next Generation Nuclear is a think tank within NII created to study the future of hydrogen, small modular reactors, and fusion energy and how these technologies might be used to help achieve a net-zero economy.

The new study will continue the center's research from last year into the potential for hydrogen production and use in Ontario and investigate the viability of a pilot project in the province's Bruce County to demonstrate the technology's economics. In addition, the study will explore what NII calls "the significant benefits a hydrogen project could bring to the region," including "new export opportunities, new trade partnerships between local vendors, and the creation of high-paying jobs."

Bruce County is well positioned to advance the hydrogen economy due to its energy expertise, geographic advantages, and natural resources, according to NII. "This project will be another step in building the region's reputation as the clean energy frontier—a place where government and private sector alike forge the path to a net-zero future," NII said.

Howard Field, chief nuclear officer of Greenfield Global, said, "As the leading producer of low-carbon transportation fuel in Canada, we are delighted to explore the potential of making clean hydrogen in a joint venture with Bruce Power, which provides clean, low-cost electricity to every third home, hospital, and business across Ontario. Our two companies have been neighbors and proud corporate citizens of Bruce County for over 30 years."

Mike Rencheck, Bruce Power's president and chief executive officer, added, "Thanks to Bruce Power and the nuclear industry, Ontario has a deeply decarbonized electricity system. We can leverage that system as a competitive advantage to attract new investment in innovation and to decarbonize other sectors of the economy through the production and use of hydrogen as a clean fuel alternative."

In Case You Missed It—Power & Operations

Unit 6 at the Tianwan nuclear plant has entered commercial operation, China National Nuclear Corporation announced in early June. The domestically designed ACPR-1000 pressurized water reactor becomes CNNC's 24th unit to enter service, raising the company's installed generating capacity to 22.5 GWe (gross).

The Tianwan-6 control room. (Photo: CNNC)

Located in China's Jiangsu Province, Tianwan is co-owned (with Atomstroyexport) and operated by Jiangsu Nuclear Power Corporation, a joint venture of CNNC, Shanghai Hexi Power Investment, and Jiangsu Guoxin Group. The plant houses four Russian-supplied AES-91 PWRs (Units 1 and 2 began commercial operation in 2007, and Units 3 and 4 came on line in 2018) and another ACPR-1000, Unit 5, which began operation in September 2020.

In addition, Units 7 and 8, both Russian VVER-1200 PWRs, are in the works at Tianwan. The first concrete pour for Unit 7 occurred on May 19. Currently, Tianwan-7 and -8 are scheduled for completion in 2026 and 2027, respectively.

EDF Energy decided to retire Dungeness B in June rather than proceed with a restart later in the year. The company had previously stated that it intended to operate the facility, located in southeastern England, until at least 2028.

The Dungeness B nuclear power station, in Kent, southeastern England. (Photo: geograph.org.uk)

Dungeness B, which houses twin 545-MWe advanced gas-cooled reactors (AGRs), had been in an extended outage since September 2018, during which time EDF had dealt with "a range of unique, significant, and ongoing technical challenges that are not found at the other six AGR power stations," according to the company.

"EDF has had to make a hard decision—but it is the right one," said John Benn, station director at Dungeness B. "It gives our teams, our community, and our business a clear understanding of the future. I'm enormously proud of everything the team at Dungeness has achieved. Our low-carbon electricity has helped Britain over the past four decades, and we have provided this part of Kent with vital jobs for generations. This marks the beginning of the next chapter in this station's story. We will now plan the defueling operations, a job we expect will take several years, and one that provides ongoing opportunities for our staff and their specialist skills."

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

Power & Operations continues

Centrus's American Centrifuge Plant, in Piketon, Ohio. (Photo: Centrus Energy)

FUEL

Centrus approved for HALEU production

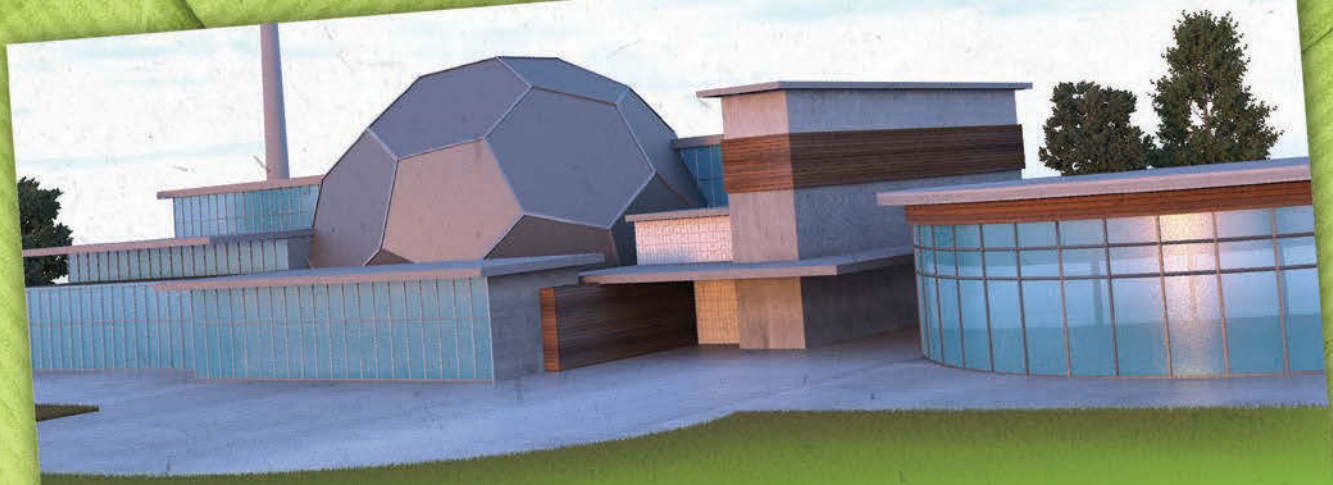
Centrus Energy Corporation on June 14 announced that the Nuclear Regulatory Commission has approved the company's license amendment request to produce high-assay low-enriched uranium at its Piketon, Ohio, enrichment facility. The Piketon plant is now the only U.S. facility licensed to enrich uranium up to 20 percent uranium-235, and it is expected to begin demonstrating HALEU production early next year, according to Centrus.

"This approval is a major milestone in our contract with the Department of Energy," said Daniel Poneman, Centrus president and chief executive officer. "We appreciate the dedicated and rigorous work of the NRC staff and commissioners in their review and approval of our license amendment request." The commission approved the request on June 11.

HALEU-based fuels will be required for most of the advanced reactor designs currently under development and may also be used in next-generation fuels for the existing fleet of reactors in the United States and around the world, the Centrus announcement stated, adding that developers of nine of the 10 advanced reactor designs selected for funding under the DOE's Advanced Reactor Demonstration Program, including the two demonstration reactors, have said that they will rely on HALEU-based fuels.

Under a 2019 contract with the DOE's Office of Nuclear Energy, Centrus is constructing a cascade of 16 AC100M centrifuges to demonstrate the production of HALEU. The three-year, $115 million cost-shared contract runs through mid-2022. Centrus, which released an update on the progress of construction of the demonstration cascade in March, anticipates completing performance under the contract in early 2022. If sufficient funding is provided to continue operation, Centrus said, the license can be amended to extend the term.

For more on HALEU, check out the article "Looking high and low for HALEU" in the September 2019 issue of *Nuclear News*, page 26.



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INL Idaho National Laboratory

U of Illinois plans to integrate research and power with advanced microreactor

Above: A rendering of Ultra Safe Nuclear Corporation's micro modular reactor as proposed for construction on the University of Illinois at Urbana-Champaign campus. (Graphic: USNC)

The U.S. state with more nuclear power plants than any other—Illinois—has no operating university research reactors. A team at the University of Illinois at Urbana-Champaign (UIUC) intends to reverse that situation and construct a high-temperature gas-cooled microreactor. If the team's plans go ahead, the first new U.S. university research reactor deployment in about 30 years could also support commercial advanced reactor deployment.

The university announced on June 28 that it had submitted a letter of intent to the Nuclear Regulatory Commission to apply for a license to construct Ultra Safe Nuclear Corporation's micro modular reactor (MMR). UIUC has been without a research reactor since 1998, when its TRIGA reactor was decommissioned. The project team has spent the past two years engaging with the university and the surrounding community; potential industry partners; and local, state, and federal governments.

Currently, the university's Abbott power station, which was originally commissioned in the 1940s as a coal-burning plant, provides about 70–75 percent of the electricity and heat required by campus buildings from both coal and natural gas–fired generation. The university's Grainger College of Engineering and the Department of Nuclear, Plasma, and Radiological Engineering are collaborating with USNC to partially repower the station using an MMR with integrated molten salt heat storage, providing a zero-carbon demonstration of district heat and power to campus buildings as part of a green campus initiative.

In addition to supporting UIUC's clean energy goals, the microreactor will serve as a valuable

workforce training tool for a new generation of nuclear scientists, engineers, and operators, according to the university. The new research and test reactor facility will offer UIUC staff and students a diverse set of opportunities for research: instrumentation and control, multi-physics validation, reactor prototype testing, micro-grid operations, cybersecurity, hydrogen production for transportation and energy storage, and other energy-intensive, high-value products.

"Universities have nearly 80 years of pioneering nuclear reactor technology and safely operating nuclear reactors," said Rizwan Uddin, head of the Department of Nuclear, Plasma, and Radiological Engineering. "Next-generation energy research facilities are critical to training the emerging clean-energy-focused workforce."

The helium-cooled, TRISO-fueled MMR can be deployed as a single reactor or multiple linked reactors, integrated with a molten salt heat storage tank and delivering heat to an adjacent power conversion plant. The reactor's molten salt heat storage can provide carbon-free high-temperature thermal energy for steam applications and for high-temperature experiments of interest to campus researchers. An MMR installation can provide about 10 to 100 MW of electrical power and/or process heat, depending on the chosen configuration. The UIUC reactor would produce 15 MWt, according to UIUC assistant professor Kathryn Huff, who has since been named the Department of Energy's deputy assistant secretary for nuclear energy.

During a September 2020 webinar forum for the university community—one of several such outreach events—Huff joined other UIUC team members to describe the university's plans, which included an application, prepared and submitted with USNC, for research and development funding through the DOE's Advanced Reactor Demonstration Program.

"This technology is at the precipice of readiness for deployment," Huff said, "and when presented with the opportunity to continue Illinois's leadership role in nuclear energy, our small team moved really quickly to spend our spring and summer crafting a proposal to DOE that a next-generation training, testing, and research reactor belongs at UIUC."

FUSION

First ITER central solenoid module ready for transatlantic journey

After a decade of design and fabrication, General Atomics (GA) is ready to ship the first module of the central solenoid—the largest of ITER's magnets—to the site in southern France where 35 partner countries are collaborating to build the world's largest tokamak and the first fusion device to produce net energy.

Earlier this year, GA completed final testing of the first central solenoid module. On June 16, the company announced that the module was being loaded onto a special heavy transport truck for shipment to Houston, where it will be placed on an oceangoing vessel for shipment to southern France. The first module was to head to sea in late July and arrive in France in late August; ground transit to the ITER site will take place in early September.

Fully assembled, the six-module central solenoid will be 18 meters (59 feet) tall and 4.25 meters (14 feet) wide and will weigh 1,000 tons. As the world's strongest magnet, the central solenoid will have a force strong enough to lift an aircraft carrier six feet into the air. At its core, it will reach a magnetic field strength of 13 teslas, about 280,000 times stronger than the earth's magnetic field. The support structures for the central solenoid will have to withstand forces equal to twice the thrust of a space shuttle liftoff, according to GA.

"This project ranks among the largest, most complex and demanding magnet programs ever undertaken," says John Smith, GA's director

Research & Applications continues

ITER CS Module 1 (shown here at right with the General Atomics fabrication team) is being loaded onto a specialized heavy transport vehicle for shipment to Houston, Texas, where it will be placed on a ship for transit to France. (Photo: General Atomics)

of engineering and projects. "I speak for the entire team when I say this is the most important and significant project of our careers. We have all felt the responsibility of working on a job that has the potential to change the world. This is a significant achievement for the GA team and US ITER."

The central solenoid modules are being manufactured at GA's Magnet Technologies Center in Poway, Calif., under the direction of the US ITER project, which is managed by Oak Ridge National Laboratory. The five additional central solenoid modules, plus a spare, are at various stages of fabrication.

Each 4.25-meter-diameter, 110-metric-ton module requires more than two years of fabrication from more than 5 kilometers (3 miles) of niobium-tin superconducting cable, according to GA. The cable is wound into flat layers that must be carefully spliced together before the module is heat treated in a large furnace. Inside the furnace, the module spends approximately 10 and a half days at 570°C and an additional four days at 650°C. Following heat treatment, the cable is insulated to ensure that electrical shorts do not occur between turns and layers. After insulation, the module is enclosed in a mold, and 1,000 gallons of epoxy resin are injected under vacuum to saturate the insulation materials and prevent bubbles or voids. When hardened at 650°C, the epoxy fuses the entire module into a single structural unit.

U.K. and Chinese national fusion programs heat up

As governments around the world cooperate on the ITER tokamak and, in parallel, race each other and private companies to develop commercial fusion power concepts, "game-changing" developments are proclaimed almost weekly. Recently, the United Kingdom and China announced new fusion program results.

The U.K. Atomic Energy Authority announced on May 26 that its MAST Upgrade experiment at the Culham Centre for Fusion Energy has demonstrated the effectiveness of an exhaust system, dubbed the Super-X divertor, that is intended to make compact fusion power plants commercially viable.

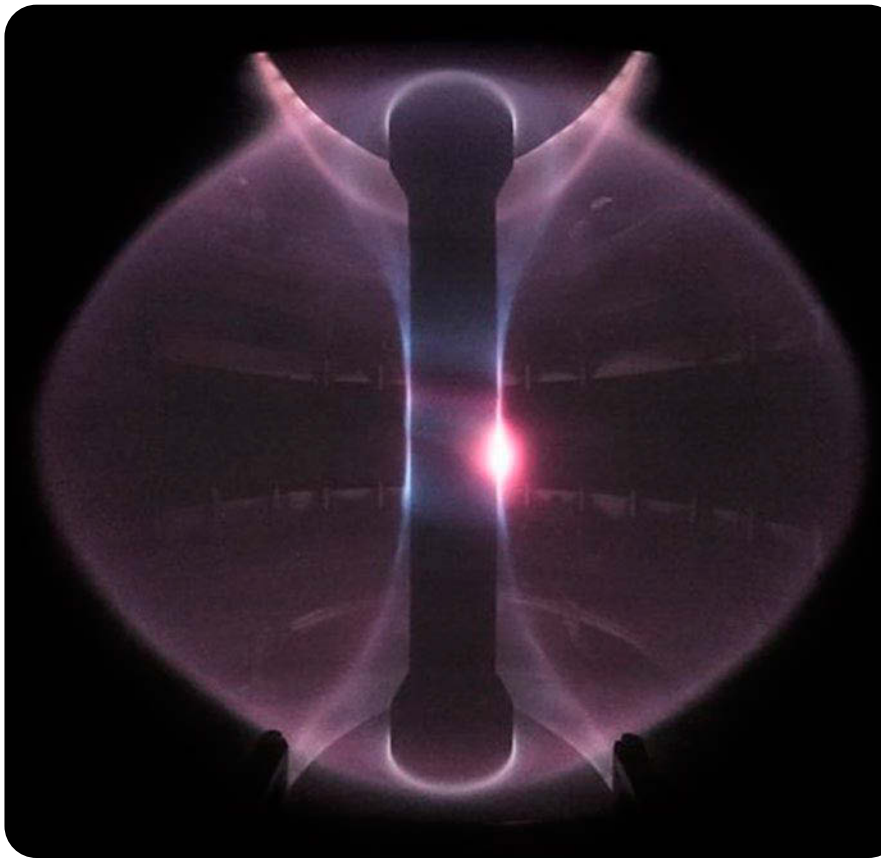
The UKAEA plans to build a prototype fusion power plant, known as STEP, by the early 2040s, using a spherical tokamak design. To pave the way, the agency recently took on the challenge of removing excess heat produced by fusion reactions. According to the UKAEA, "Without an exhaust system that can handle this intense heat, materials will have to be regularly replaced—significantly affecting the amount of time a power plant could operate for."

Tokamak fusion devices feature a divertor region that acts as an exhaust system, steering excess heat and particles from the fuel out of the plasma chamber. The Super-X divertor that is being tested at the MAST Upgrade experiment would, according to the UKAEA, increase the power plant's availability, improve its economic viability, and reduce the cost of fusion electricity.

A video released by the UKAEA compares the divertor in a tokamak to an exhaust pipe on a conventional car, explaining that the Super-X divertor essentially gives a fusion tokamak a longer exhaust pipe to remove heat and prevent heat damage to plasma-facing components. Testing at the MAST Upgrade, which began operating in October 2020, found that Super-X can reduce the heat on materials by at least 10 times, according to the UKAEA.

■ Chinese news agency Xinhua announced on May 28 that researchers at the Institute of Plasma Physics of the Chinese Academy of Sciences' Experimental Advanced Superconducting Tokamak (EAST) have set a new world record, achieving a plasma temperature of 120 million degrees Celsius for a period of 101 seconds. The EAST tokamak, which is located in Hefei, the capital of east China's Anhui Province, also achieved a plasma temperature of 160 million degrees Celsius, lasting for 20 seconds, according to Xinhua. In 2020, EAST claimed a plasma temperature of 100 million degrees Celsius lasting for 20 seconds.

Research & Applications continues



Plasma in MAST. (Photo: UKAEA/EUROfusion)

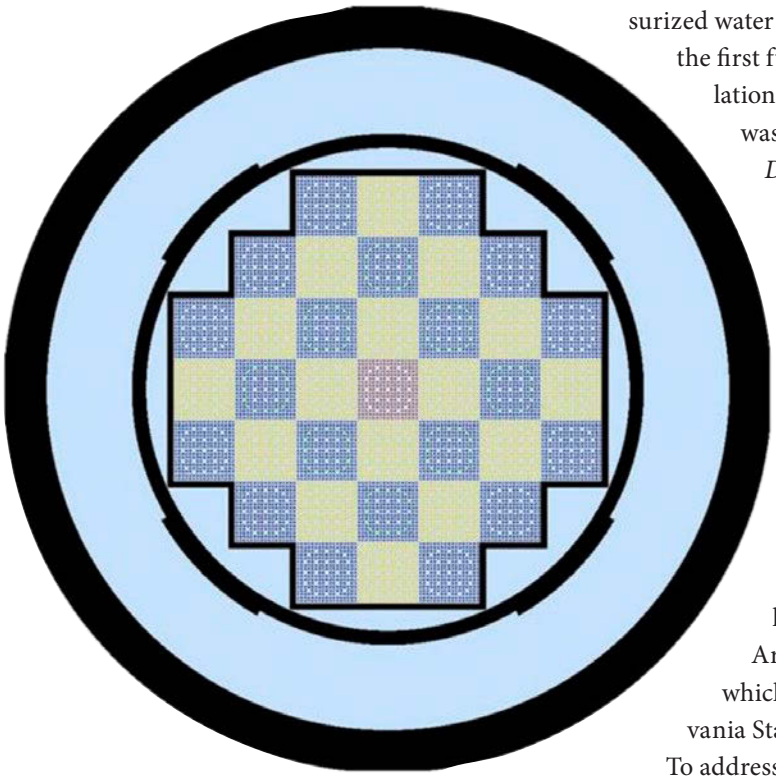
In this April 2021 photo, staff members perform an upgrade to China's Experimental Advanced Superconducting Tokamak (EAST). (Photo: Xinhua)

ADVANCED MODELING

Argonne-led team models fluid dynamics of entire SMR core

Coolant flow around the fuel pins in a light water reactor core plays a critical role in determining the reactor's performance. For yet-to-be-built small modular reactors, a thorough understanding of coolant flow will be key to successfully designing, building, and licensing first-of-a-kind reactors.

Scientists at Argonne National Laboratory have collaborated to develop a new computer model that allows for the visualization of complex flow-structure interactions in a full pressurized water SMR core at unprecedented resolution and have published the first full-core pin-resolved computational fluid dynamics simulation. The milestone in the modeling project known as ExaSMR was published on April 5 in the journal *Nuclear Engineering and Design* and was described by Argonne in a June 7 press release.



This image shows the individual pins in a full-core nuclear reactor simulation. (Image: Argonne)

Limitations in raw computing power have constrained past models to specific regions of a reactor core. Large-scale, high-resolution models can yield better information about the behavior of these reactors in the high-pressure, high-temperature, and radioactive environments of the core, and better information could drive down costs to deployment.

"As we advance toward exascale computing, we will see more opportunities to reveal large-scale dynamics of these complex structures in regimes that were previously inaccessible, giving us real information that can reshape how we approach the challenges in reactor designs," said Argonne nuclear engineer Jun Fang, an author of the study, which was published by ExaSMR teams at Argonne and Pennsylvania State University.

To address the impact of spacer grids, which create turbulent flow to enhance heat removal in PWRs, the researchers developed a mathematical reduced-order methodology to mimic the overall impact of these structures on the coolant flow without sacrificing accuracy, according to Argonne. The method allows the researchers to scale up the simulations to an entire SMR core.

"The mechanisms by which the coolant mixes throughout the core remain regular and relatively consistent," said Argonne principal nuclear engineer Dillon Shaver. "This enables us to leverage high-fidelity simulations of the turbulent flows in a section of the core to enhance the accuracy of our core-wide computational approach."

The team's computations were carried out on supercomputers at the Argonne Leadership Computing Facility, the Oak Ridge Leadership Computing Facility, and Argonne's Laboratory Computing Resource Center. The ultimate objective of the ExaSMR project, being conducted under the DOE's Exascale Computing Project, is to carry out full-core multiphysics simulations on upcoming cutting-edge exascale supercomputers, such as Aurora, which is scheduled to arrive at Argonne in 2022.

UNIVERSITY PROGRAMS

Nuclear R&D technology projects get $61 million in DOE funding

More than $61 million in funding has been released for advanced nuclear energy technology projects in 30 states and in the U.S. territory of Puerto Rico, the Department of Energy announced on June 22. Of that total, $58 million is going to U.S. universities for nuclear energy research, cross-discipline technology development, and research reactor infrastructure.

The funds are being distributed through established DOE nuclear energy programs: the Nuclear Energy University Program (NEUP), Nuclear Energy Enabling Technologies (NEET), and Nuclear Science User Facilities (NSUF).

The bulk of the awards is being granted through NEUP. A total of 69 university-led projects across 27 states are receiving $48.8 million in DOE funding for nuclear energy research, including novel methods for the treatment and storage of nuclear waste. In addition, 24 university-led projects will receive a combined total of $5.9 million for research aimed at improving nuclear reactor infrastructure and providing crucial safety and performance upgrades to a portion of the nation's 25 university research reactors.

Four projects awarded through NEET and NSUF—and separately housed at Iowa State University, North Carolina State University, GE Research, and Oak Ridge National Laboratory—will develop advanced materials, manufacturing, and digital instrumentation technologies to support advanced nuclear reactors and to investigate the application of nuclear

Research & Applications continues

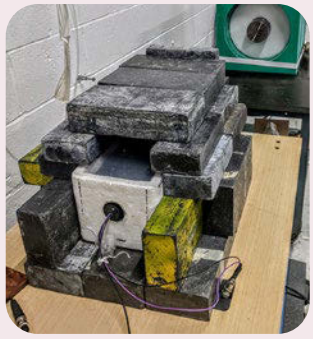
fuel and materials. These projects are receiving $3.2 million and will be supported by about $3.9 million in facility access costs and expertise for experimental neutron and ion irradiation testing, post-irradiation examination facilities, synchrotron beamline capabilities, and technical assistance for the design and analysis of experiments through NSUF.

With these latest fiscal year 2021 awards included, since 2009 the DOE's Office of Nuclear Energy has awarded more than $863 million to train the next generation of nuclear scientists and engineers through competitive opportunities.

"Nuclear power is critical to America's clean energy future, and we are committed to making it a more accessible, affordable, and resilient energy solution for communities across the country," said energy secretary Jennifer Granholm. "At DOE, we're not only investing in the country's current nuclear fleet, but we're also investing in the scientists and engineers who are developing and deploying the next generation of advanced nuclear technologies that will slash the amount of carbon pollution, create good-paying energy jobs, and realize our carbon-free goals."

In Case You Missed It—Research & Applications

An MIT team has developed a mobile neutron resonance transmission analysis device, permitting the detection technology developed on laboratory-scale equipment at Los Alamos National Laboratory to examine materials on location, which could be useful for national security purposes. The team used a deuterium-tritium generator to direct neutrons through a tube at the target material, with a detector placed behind the target. In contrast to the apparatuses at national labs, which can reach hundreds of meters in length, the team's entire setup occupied just 3 meters and could be moved by one person. The researchers published their results on May 13 in *Physical Review Applied*.



Experimental setup including a shielded detector. (Photo: MIT)

Machine learning makes predicting fusion profiles faster, researchers at the Department of Energy's Princeton Plasma Physics Laboratory have found. They are using machine learning to predict electron density and pressure profile shapes on the National Spherical Torus Experiment-Upgrade (NSTX-U), the flagship fusion facility at PPPL that is currently under repair. The hope is that such predictions, generated by artificial neural networks, could improve the ability of NSTX-U researchers to optimize the components of experiments that heat and shape the fusion plasma.

PPPL physicist Dan Boyer. (Photo: Amber Boyer/Kiran Sudarsanan)

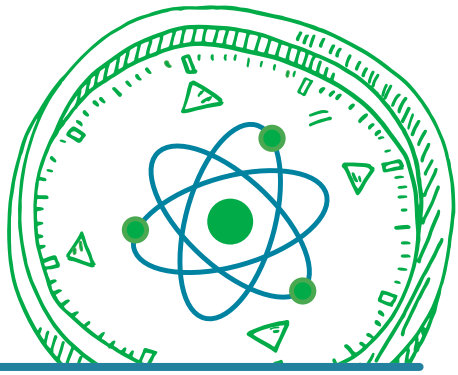
For in-depth coverage of these stories and more, see ANS's* Nuclear Newswire *at ans.org/news.

Navigating Nuclear Reaches the Milky Way in New Virtual Field Trip

Navigating Nuclear: Energizing Our World™, ANS's K-12 education program, has extended its reach to outer space with the launch of our latest virtual field trip —***Nuclear Frontiers: Powering Possiblity***—available on demand at navigatingnuclear.com.

The Navigating Nuclear curriculum, developed in partnership with the Department of Energy Office of Nuclear Energy and Discovery Education, includes resources for all grade levels such as digital lessons, project starters, and career profiles, as well as virtual field trips to Palo Verde Generating Station and Idaho National Laboratory.

To date, the program has reached more than 1.5 million students!



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U.K. reaches deal with EDF on decommissioning AGRs

The U.K. government and EDF have agreed to improved arrangements for the decommissioning of Britain's seven advanced gas-cooled reactor nuclear power plants, which are due to reach the end of their operational lives this decade.

Under the revised arrangements, negotiated by the government with EDF and signed on June 23, the AGR stations will transfer to the U.K.'s Nuclear Decommissioning Authority after EDF has ceased power generation and defueled the plants, subject to regulatory approvals. The NDA will take ownership of the plants and manage the long-term decommissioning program, with Magnox Ltd. as the new site license company.

According to the U.K. government, these arrangements will harness EDF's expertise in defueling the AGRs and NDA's experience of decommissioning nuclear plants and facilities in the United Kingdom. The NDA is currently decommissioning the U.K.'s older Magnox reactors.

"We are delighted to have been directed by government to take on the future ownership of the seven EDF advanced gas reactor sites for future decommissioning," said David Peattie, chief executive of the NDA. "This work is of national importance and we now look forward to working with EDF to ensure the seamless transfer of stations in the coming years."

EDF announced earlier in June that it was moving its Dungeness B nuclear plant in Kent into its defueling phase "with immediate effect," rather than proceeding with a restart later this year. The company said that, in a best case, it anticipates being able to carry out some "low rate defueling" of Dungeness B in the second half of 2022.

Hunterston B's pile cap and fueling machine. (Photo: EDF)

EDF's Hunterston B in Scotland is the first AGR plant to start defueling—by January 2022—followed by Hinkley Point B (Somerset) in mid-2022. EDF said that Heysham 1 (Lancashire) and Hartlepool (Teesside) are both due to begin defueling in March 2024, and the current expectation is that Torness (Scotland) and Heysham-2 will begin defueling by 2030.

EDF will continue to use the U.K.'s Nuclear Liabilities Fund, which receives and holds monies, investments, and other assets in a segregated decommissioning fund

established by the government, to defuel the AGR sites. The new streamlined arrangement is expected to save the taxpayers an estimated £1 billion (about $1.4 billion), according to the U.K.'s Department for Business, Energy, and Industrial Strategy (BEIS). The NDA's expertise and the economies of scale of working on the combined Magnox and AGR sites will ensure the long-term cleanup of these sites is done more efficiently, the BEIS said.

"We are committed to delivering value to the taxpayer via the NLF and the revised arrangements provide the certainty we need to plan and deliver safe and cost-effective defueling," said Simone Rossi, EDF chief executive. "The arrangements also provide our employees and supply chain partners important clarity over jobs for the coming years."

The BEIS also said that closure of the AGR plants will not affect the U.K.'s energy supply, as energy from renewables has more than quadrupled since 2010. The U.K. government has also committed to making a final investment decision on at least one large-scale nuclear power plant, alongside harnessing new and advanced nuclear technology.

SAVANNAH RIVER SITE

DOE prepares for dissolution of stainless-steel-clad spent nuclear fuel

The Department of Energy is preparing for an upcoming campaign to dissolve stainless-steel-clad spent nuclear fuel at its Savannah River Site in South Carolina by installing a new dissolver and an additional double-sized tank for storing dissolved material. Workers with site contractor Savannah River Nuclear Solutions (SRNS) are making room for the new equipment by disposing of old equipment at Savannah River's H Canyon, the only operating production-scale chemical separations facility in the United States.

"The upcoming dissolving campaign will add a third electrolytic dissolver to the complement of equipment already in use in the canyon and will provide the capability to dissolve stainless-steel fuel," said Wyatt Clark, SRNS senior vice president of environmental management

A train pushes a container full of old equipment from H Canyon to a Savannah River Site disposal facility to make way for a new spent nuclear fuel dissolving campaign. (Photo: DOE)

Waste Management continues

operations. "The current chemical dissolvers are designed to dissolve aluminum-clad fuel, so they are not adequate to support the upcoming mission."

Savannah River's stainless-steel-clad spent fuel is currently stored in the site's K Area and will be shipped to H Canyon for processing. Once the fuel is dissolved in the electrolytic dissolver, the resulting solution will be transferred to the liquid waste tank farms. The material will then be transferred to the Defense Waste Processing Facility, where it will be vitrified and placed in an SRS facility for interim storage.

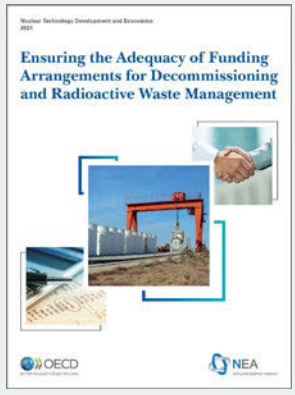
According to the U.S. Nuclear Waste Technical Review Board, Savannah River holds approximately 20 metric tons (about 2,000 fuel assemblies) of non-aluminum-based spent fuel, including zirconium-alloy-clad, stainless-steel-clad, and de-clad thorium oxide and uranium oxide or uranium-zirconium alloy. The spent nuclear fuel is primarily from research and test reactors.

In preparation for the processing mission, crews at H Canyon recently finished removing the first of three shipments of legacy equipment to make room for the new campaign.

According to Richard Brown, an SRNS project manager, the old equipment is placed in large,

In Case You Missed It—Waste Management

A new approach to funding the back end of the nuclear fuel cycle is being proposed by the OECD Nuclear Energy Agency, which has issued a report on assessing the financial adequacy for undertaking nuclear decontamination and decommissioning projects and high-level radioactive waste management.



The report, *Ensuring the Adequacy of Funding Arrangements for Decommissioning and Radioactive Waste Management*, argues that the current "linear" approach to assessing financial adequacy, which is based on the linear discounting of estimated future costs for decommissioning and waste disposal, should be complemented with a broader "circular" approach, in which funding arrangements continuously adapt as new information on costs, social preferences, policy objectives, lifetimes, or rates of return on existing assets becomes available.

The report was released on June 18 and can be found at the NEA website, oecd-nea.org.

The IAEA has issued an assessment of Japan's decommissioning program for nuclear research and development facilities and is recommending that Japan prepare for delays in the development of disposal facilities and provide appropriate waste storage capacity for the interim period. The recommendation was one of several that a team of International Atomic Energy Agency experts provided to the Japan Atomic Energy Agency after reviewing the agency's 70-year decommissioning program, called the "Back-End Roadmap," and contained in the report *ARTEMIS Review of JAEA Back-End Roadmap*, which was released on June 22.

The report, which can be found at iaea.org, was the outcome of an Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS) review, April 12–22, requested by Japan's government.

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

engineered packages, called burial boxes, using the canyon's remote cranes. "Once that box is full, we secure the package, verify it is free of any radioactive contamination, and transfer it to the SRS Solid Waste Management Facility for disposal," he said.

Preparations for the new campaign also include preparing and calibrating the double-sized tank and new dissolver with the use of a bladder tank and pump system. The use of the bladder tank and pump system speeds up the calibration process by pumping water instead of using a domestic water hose to fill the 50- and 150-gallon prover tanks, which are vessels used to add a specific volume of water to the tanks being calibrated.

HANFORD

Final stages of cleanup resumes at Hanford's PFP

Final cleanup activities at the Hanford Site's demolished Plutonium Finishing Plant have resumed following a pause in work prompted by the COVID-19 pandemic, the Department of Energy announced in June. Crews with the DOE's Richland Operations Office and site contractor Central Plateau Cleanup Company will remove, package, and dispose of rubble remaining from the demolition of the plant's plutonium reclamation facility, which was torn down in 2017.

"PFP demolition forever changed the skyline at Hanford," said Bob Nichols, director for Central Plateau Cleanup Company's inner area end states group.

Rubble removal and packaging was about 25 percent complete when the work was halted and the site was placed in a safe configuration in March 2020, when Hanford entered an essential mission-critical operations posture in response to the pandemic.

In operation from 1949 to 1989, the Plutonium Finishing Plant was the last step in plutonium production at the Hanford Site, near Richland, Wash. Open-air demolition of the PFP began in 2016, and the plant's last remaining structure, the main processing facility, was torn down in February 2020.

A loaded waste container at the site of the former Plutonium Finishing Plant is surveyed to ensure that it is safe for transfer to Hanford's on-site disposal facility. (Photo: DOE)

The packaged rubble will be transferred to the Environmental Restoration Disposal Facility, Hanford's on-site engineered landfill, for permanent disposal, the DOE said. The site grounds will then be stabilized with a protective cover that will limit the effects of water, wind, and heat.

"This critical risk-reduction work builds on the incredible accomplishment of completing demolition of the PFP main processing facility in early 2020," said Tom Teynor, project director for PFP demolition in the Richland Operations Office.

Waste Management continues

NRC

Challenges to TMI-2 license transfer, ISP's license application dismissed

The Nuclear Regulatory Commission has dismissed a challenge to the previously approved transfer of the license for the shuttered Three Mile Island-2 power reactor from FirstEnergy to a subsidiary of EnergySolutions for decommissioning. The order by the NRC commissioners denying the motion by Three Mile Island Alert to hold the license transfer in abeyance was issued on June 22.

Three Mile Island-2. (Photo: DOE)

At the same time, the NRC commissioners rejected a petition challenging a license application by Interim Storage Partners, a joint venture of Waste Control Specialists and Orano USA, to build and operate a consolidated interim storage facility for spent nuclear fuel in Andrews County, Texas. Fasken Land and Minerals and Permian Basin Land and Royalty Owners (together referred to as Fasken) had appealed an earlier order by an NRC licensing board that threw out the challenge to ISP's application.

The NRC staff approved the TMI-2 license transfer in December 2020, and the following month the commissioners denied a petition by TMI Alert and its chairman, Eric Epstein, to intervene and request a hearing, terminating the proceeding. On March 15, however, the group filed a motion to temporarily suspend the license transfer, arguing that the applicants, the NRC, the Pennsylvania Department of Environmental Protection, and others did not comply with portions of the Clean Water Act. TMI Alert said that those issues should have been resolved before the license was transferred.

In denying the motion, the NRC commissioners said that because the staff had already approved the license transfer and an order denying TMI Alert's initial petition had been issued, they no longer have jurisdiction over the matter.

"As we have described in previous cases, after the staff issues the action provided for in the notice of opportunity for hearing and we issue our final adjudicatory decision, we no longer retain jurisdiction to consider further adjudicatory filings," the commissioners said in their order to dismiss.

Moreover, the commissioners said that even if they did have jurisdiction, TMI Alert's motion fails to meet the requirements for reopening the case or for staying the license transfer.

In upholding the board's decision to deny the challenge to ISP's license application, the commissioners said that Fasken "has not shown that the board erred or abused its discretion and therefore has not raised a substantial question warranting review."

Fasken filed the challenge to ISP's license application in July 2020, after the deadline to intervene had passed. Fasken filed the late challenge and moved to reopen the case because it claimed that the NRC staff's draft environmental impact statement, issued in May 2020, contained new information concerning transportation routes that justified its challenge. The licensing board, however, was not swayed by Fasken's arguments and denied the contention.

The NRC commissioners, also finding Fasken's arguments unpersuasive, denied the appeal.

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Meet the new ANS Board members

Three newly elected and three newly appointed members of the ANS Board of Directors began their terms on June 16 during the 2021 ANS Virtual Annual Meeting. Keep reading to learn more about the new directors.

JULIE G. EZOLD

The basics: Ezold, ANS member since 1992, is the Radioisotope Production and Operations Section head, as well as the californium-252 production manager, at Oak Ridge National Laboratory.

Accolades: ANS honored Ezold with a Presidential Citation in 2009, and in 2019, she received ANS's E. Gail de Planque Medal for the advancement of radioisotope production leading to the synthesis of new elements, and for contributions to space exploration and to the training of a new generation of nuclear scientists. Among her other honors, Ezold received the Patricia Bryant Leadership Award from U.S. Women in Nuclear in 2009.

Board goals: Ezold has several objectives to accomplish during her three-year term. Among them are to continue the efforts for expanding the membership with more inclusive and engaging messaging and actions, ensure the solvency of ANS scholarships to support future members, expand K-12 outreach efforts to attract students to nuclear science, and provide opportunities for all levels of membership to participate in the governance of the Society.

Bet you didn't know: Ezold enjoys spending time with her 12-year-old daughter; their two cats, Simba and Bagheera; and their shelter dog, Avalon. She also occasionally plays the piano.

JESS C. GEHIN

The basics: Gehin, ANS Fellow and member since 1993, is the associate laboratory director for nuclear science and technology at Idaho National Laboratory. He joined INL in 2018 after spending 26 years at Oak Ridge National Laboratory.

Board goals: As a Board member, Gehin has four goals in mind for his term. The first is for ANS to support the changing energy landscape to ensure that nuclear energy plays a strong role. The second is to maintain the strong technical base of ANS through its professional divisions and publications. The third is to see ANS increase its voice and input to decision makers by providing a clear message on the importance of nuclear energy to the nation's future. Finally, he wants to enable broad participation by ensuring that the Society is inclusive and serves a diverse membership.

Bet you didn't know: Gehin enjoys camping, hiking, and winter sports, which makes Idaho an ideal place for him to live, along with his wife of more than 30 years, Ann, and their son, Spencer. He also enjoys cooking and used the pandemic as a time to work on his cooking skills. Lately he has focused on Asian cooking and said he really enjoys a good bowl of ramen.

JOHN M. MAHONEY

The basics: Mahoney, ANS member since 2008, is the president and chief operating officer of High Expectations International, a company he cofounded 10 years ago.

Stepping in: Mahoney was appointed by the Board to serve the remainder of Steven Arndt's term. Arndt was elected ANS vice president/president-elect in April, thus creating the vacancy. Mahoney will serve a two-year term.

He said it: "I've been a part of making things happen for years, and joining the ANS Board seems to be an opportunity that aligns with my convictions concerning education, science, and technology. I think we can have a positive impact for the future."

Bet you didn't know: After losing their two chihuahuas to old age last year, Mahoney and his wife, Lynn, adopted two shelter dogs in December through Animal Rescue New Orleans. They now have Tilly, a chihuahua and dachshund mix called a "cheeweeny," and Lilly, who is part chihuahua and part pug, called a "chug." Mahoney said that maybe the dogs are the ones who did the adopting.

CATHERINE M. PRAT

The basics: Prat, ANS member since 2011, has worked as the initial test program engineering lead at Westinghouse Electric's Vogtle plant for the past two years.

A new role: The young member director position was created in 2020, making Prat the first to serve on the Board in that capacity. The position carries a full three-year term like the others.

Board goals: Prat wants to bring the young members' voice to the Board to ensure forward-thinking and the implementation of policies that will serve those that represent the future of the Society.

Bet you didn't know: Prat says her family takes "nuclear nerd" to a new level. She met her husband while they were working on the construction of the first Westinghouse AP1000 pressurized water reactor in Sanmen, China. They moved back to the United States to work on the construction of Vogtle Units 3 and 4. They welcomed a son in 2019 and are expecting a second son at the end of the summer. Prat said that doesn't leave much time for hobbies, joking that her life of late revolves around fluid dynamics—both the baby variety and the reactor coolant loop variety.

JESSIKA V. ROJAS

The basics: Rojas, ANS member since 2015, is an associate professor in the Department of Mechanical and Nuclear Engineering at Virginia Commonwealth University. She joined VCU in 2014 as an assistant professor and was recently promoted.

Appointment: Rojas was appointed by the Board to replace Kathryn D. Huff and will serve a three-year term. Huff was elected to the Board in April but declined the seat after accepting a leadership position with the Department of Energy's Office of Nuclear Energy.

Board goals: Rojas said she is looking forward to working with ANS in the activities and strategic planning that support its mission and vision in the various fields of nuclear science and technology. Being in academia, Rojas is eager to promote outreach activities within the Society to make an impact on the nuclear community, as well as supporting collaborative environments between student sections and local sections within ANS.

Bet you didn't know: She enjoys traveling with her husband and daughter and seeing new places. But a favorite place to visit is still her hometown in Colombia to spend time with family and friends, as well as to enjoy the weather and the food there.

TRACY E. STOVER

The basics: Stover, ANS member since 2007, is a principal engineer in the criticality safety group at Savannah River Nuclear Solutions, where he has worked for six and a half years.

The position: He was appointed by the Board to fill the vacancy created by the death of Peter Lyons in May. Stover will serve a one-year term.

Board goals: Stover believes that ANS needs to focus on a more professionally diverse membership and strengthen its fundamental base. He would like to see more members become active in discipline-specific divisions. He also wants to see ANS focus on maintaining and expanding strong local and student sections. Finally, he wants to see ANS expand its industrial diversity beyond commercial power into the many facets of the industry, including untapped professionals such as radiological workers, industrial users of radioisotopes, and niche fields.

Bet you didn't know: Stover and his wife, Maria, have two sons, two-year-old Preston and seven-month-old Henry, who take up his free time right now. They also have a small poodle mix who spends most of her time hiding from the two-year-old. Active sea cruisers—mostly in the Caribbean—before the pandemic, he and his family are looking forward to the ships sailing again soon.

AMANDA M. BACHMANN

The basics: Bachmann, ANS member since 2016, is a graduate research assistant at the University of Illinois at Urbana-Champaign. She started in that position in August 2020 after earning her bachelor's and master's degrees in nuclear engineering from the University of Tennessee.

Board goals: Bachmann said she hopes to be a strong voice for the student members, to help ensure that

ANS News continues

post–Change Plan actions will benefit students, and to position ANS in a way to help future generations. She also hopes to empower more student participation across the Society, such as in divisions and committees, by ensuring that students are well informed of society activities and positions.

Hobbies: Her hobbies include watching sports (just about any sport), knitting and crocheting gifts for friends, and playing with her rabbit, named Rontgen. She says her hobbies serve as a distraction from the stress of grad school.

Bet you didn't know: Bachmann earned the Girl Scout Gold Award in 2015, the highest award given by the Girl Scouts of the USA. Fewer than 6 percent of eligible Girl Scouts earn the Gold Award each year. Bachmann received her award for the Luck of the Irish Food Drive, which resulted in more than 800 pounds of food for Metropolitan Ministries in Florida.

Last call for 2022 ANS election nominations

Each year, ANS leaders are nominated and elected from among the dedicated nuclear technology professionals that make up the Society's membership. Now is your chance to nominate candidates to run in the 2022 ANS national election for the office of vice president/president-elect and for six seats on the ANS Board of Directors. All terms will begin in June 2022.

The ANS presidency traditionally rotates between the university, national laboratory, utility, and supplier sectors. This year, ANS is seeking qualified individuals from U.S. nuclear utilities for the 2022 vice president/president-elect position. Five of the six director seats are for U.S. resident candidates; the remaining seat will be filled by a non-U.S. member.

Nominations are due by August 6 and must include a CV or biographical information to be valid for consideration. Send your nominations to Mary Lou Dunzik-Gougar, chair of the ANS Nominating Committee, via committee staff liaison Aubrey Whittington (awhittington@ans.org).

ANS teams with WIN, NAYGN, NEI to launch I4N-NA contest

The American Nuclear Society has joined with Women in Nuclear, the North American Young Generation in Nuclear, and the Nuclear Energy Institute to launch the Innovation for Nuclear in North America (I4N-NA) contest.

The idea of the contest is to encourage and challenge young professionals to be innovative and take charge in creating sustainable solutions to the problems the world faces. The purpose of I4N-NA is to reward innovative ideas focused on nuclear technologies or applications that will contribute to the United Nations' Sustainable Development Goals.

The contest is open to students and young professionals currently living in North America (United States, Canada, and Mexico). Teams can be made of up to four members who are under 40 in 2022. The contest will be conducted in three phases, with the winners announced at the 2021 ANS Winter Meeting. The winning team will receive a travel grant to participate in the international I4N finale at the International Youth Nuclear Conference 2022 in Sochi, Russia.

For more information, visit the NAYGN website (naygn.org).

ANS HFIC Division names 2021 award winners

The American Nuclear Society's Human Factors, Instrumentation and Controls Division (HFICD) has named the recipients of three divisional awards that were presented during the opening plenary session of the 12th Nuclear Plant Instrumentation, Control and Human-Machine Interface Technologies topical meeting, held in conjunction with the 2021 ANS Virtual Annual Meeting in June. These awards are given annually to members of the HFICD that have demonstrated outstanding contributions to the areas of nuclear instrumentation and controls, human factors engineering, or human-machine interface. Read about this year's recipients below.

For more information on the HFICD awards, please visit the ANS Honors and Awards page at ans.org/honors or contact the HFICD Honors and Awards Chair, Brent Shumaker, at brent@ams-corp.com.

DON MILLER PROFESSIONAL MEMBER AWARD, two recipients

Ron Boring, distinguished scientist and manager of the Human Factors and Reliability Department at Idaho National Laboratory, in recognition of his outstanding contributions to the nuclear industry's human factors community, especially in the areas of human reliability analysis, system design, and evaluation.

Rizwan Uddin, professor and head of the Nuclear, Plasma, and Radiological Engineering Department at the University of Illinois at Urbana-Champaign, in recognition of his leadership in technical training, effective control room and operations design, human factors research, and the development of 3D interactive "environments" for student learning.

H. M. HASHEMIAN MID-CAREER AWARD

Sacit Cetiner, senior research scientist in Idaho National Laboratory's Measurement Sciences Department and director of the Center for Reactor Instrumentation and Sensor Physics at the Massachusetts Institute of Technology, in recognition of his outstanding technical contributions to the field of measurement science, including instrumentation, control, and data science.

TED QUINN EARLY CAREER AWARD

Fan Zhang, research assistant professor in the Department of Nuclear Engineering at the University of Tennessee–Knoxville, in recognition of her contributions to the research and development community for nuclear science and technology with emphasis on instrumentation and control and cybersecurity requirements and controls.

ANS News continues

New Members

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

Allory, Mathieu
Alvarado, Rossnyev, Nuclear Regulatory Commission
Anderson, Patricia W.
Anderson, Shaun, Nuclear Regulatory Commission
Apresa, Justin A.
Archambo, Neil, Duke Energy Corporation
Armstrong, Matthew C.
Arregui-Mena, Jose D., Oak Ridge National Laboratory
Ashcraft, Joseph M., Nuclear Regulatory Commission
Ashkeboussi, Nima, Nuclear Energy Institute

Bailey, David, SHINE Medical Technologies
Bajaj, Nikhil, University of Pittsburgh
Bakken, Rodney, Barnhart Crane & Rigging
Banford, Anthony, National Nuclear Laboratory (U.K.)
Barroso, Javier, Tecnatom (Spain)
Benner, Eric, Nuclear Regulatory Commission
Blanchard, David, Pacific Northwest National Laboratory
Bollinger, Tim, Mackson Nuclear
Bowman, Douglas
Brown, Richard, Canadian Nuclear Laboratories
Browne, Michael, Los Alamos National Laboratory
Brownfield, Ryan, Texas A&M University
Bryant, David, Oak Ridge National Laboratory
Buckland, Heath
Buller, Dane, Rolls-Royce (U.K.)
Busch, Richard C., RCB Research
Busquim e Silva, Rodney, International Atomic Energy Agency

Cameron, Diane, Nuclear Energy Agency
Carroll, Thomas, Fourthriver Resources
Castelveter, David A., Nuclear Regulatory Commission
Chamberlin, Rebecca, Los Alamos National Laboratory
Champlin, Patrick, Oak Ridge National Laboratory
Chan, Cindy
Chapel, Shay, Oak Ridge National Laboratory
Che, Shuai, University of Michigan
Chen, Kevin, University of Pittsburgh
Chesebro, Jonathan, U.S. Department of Commerce
Chhiba, Priya, Enercon
Chokshi, Nilesh C.
Coles, Garill A., Pacific Northwest National Laboratory
Compton, Christopher, Duke Energy
Cooper, Richard, Thinklogical
Coppock, Glenn, UT-Battelle
Corbin, Robert A., TerraPower
Cowan, Pamela, Holtec International
Cowell, Brian, Oak Ridge National Laboratory
Cowles, David, MPR Associates
Coyne, Kristen, Oak Ridge National Laboratory
Cretinon, Laurent, EDF (France)

Dahunsi, Stephen, Oak Ridge National Laboratory
Dainoff, Marvin J., Marvin J. Dainoff LLC
Danjaji, Musa B.
Davydov, Jerry, Los Alamos National Laboratory
DeForest, Tom, Pacific Northwest National Laboratory
DePodesta, Karen
Derr, Kurt, Idaho National Laboratory
Devereux, Michael, University of Strathclyde (U.K.)
Dixon, Brent W., Idaho National Laboratory
Dunkin, Bradley, Advanced Manufacturing Solutions
Durot, Christopher, University of Michigan

Eckhart, Brian, Oak Ridge National Laboratory
Egidi, Philip, Environmental Protection Agency
Eiler, Janos, International Atomic Energy Agency
Erickson, Steven
Ericson, M. Nance, Oak Ridge National Laboratory
Eun, Jongwan, University of Nebraska–Lincoln

Farber, Jacob A. K., Idaho National Laboratory
Fei, Zhouxiang, University of Strathclyde (U.K.)
Felix, Sunil, Embassy of France
Ferree, Codi R., Analysis and Measurement Services
Finan, Ashley
Flamand, Ryan S., NuScale Power
Flanagan, Dylan
Foster, Mandy, Tennessee Valley Authority
Frame, Lesley, University of Connecticut
Frazier, William E., Pacific Northwest National Laboratory
Frost, Sandra L., Los Alamos National Laboratory
Fujii Yamagata, Alessandra L., Pacific Northwest National Laboratory
Fuld, Robert B.
Fulton, John, Sandia National Laboratories

Gadey, Harish R., Pacific Northwest National Laboratory
Gadi, Ravi, Oak Ridge National Laboratory
Garcia, Ismael L., Nuclear Regulatory Commission
Garcia, Ricardo, Tecnatom (Spain)
Gardner, Darrell, Kairos Power
Garner, Jim, Oak Ridge National Laboratory
Gaulin, Abigail
Gavello, Molly-Kate
Gavlik, Ken E., Philotechnics
Geltman, Elizabeth, City University of New York School of Public Health
Geringer, Robert J., Evergy
Ghaddar, Tarek, Oak Ridge National Laboratory
Gibbs, Philip W., Oak Ridge National Laboratory
Gibson, Matt, Electric Power Research Institute
Godfrey, Luke, Moltex Energy (Canada)
Goetz, Callie, Oak Ridge National Laboratory
Golovich, Elizabeth, Pacific Northwest National Laboratory
Gorecke, Kevin, Pacific Northwest National Laboratory
Gorman Prochaska, Pamela, Xcel Energy
Granado, Alice, G.D. Barri & Associates
Grosch, Gustav, Imperia Engineering Partners
Gui, Yifan, University of Michigan
Gupta, Puja, General Atomics

Hack, Bruce
Haley, John, Tennessee Valley Authority
Hall, Anna, Braveheart Solutions
Hamilton, David E., University of Utah
Han, Hun Sik, Korea Atomic Energy Research Institute (South Korea)
Hancock, Stephen G., Idaho National Laboratory
Hansen, Joseph T.
Hansink, Matthew, Battelle Energy Alliance
Hanson, Kevin
Harper, Jeff, X-energy
Hasan, Hasanain S., Exelon Corporation
Hauptman, Sara, Massachusetts Institute of Technology
Hawkins, Gary, Ultra Electronics Energy
He, Lingfeng, Idaho National Laboratory
Heffner, Mary, Duke Energy
Herrell, David C., MPR Associates
Hervas Martin, Borja, Tecnatom (Spain)
Hickey, Kevin S.
Hickman, Bill, Day & Zimmermann
Hill, Rachael, Idaho National Laboratory
Hinaman, Mark, Franklin Mountain Energy
Hiruta, Mie, JFoster & Associates
Ho, Alfred, TerraPower
Howard, Christianna, Southern Nuclear Company
Howe, Troy, Howe Industries
Huan, Xun, University of Michigan
Huber, Zachary, Pacific Northwest National Laboratory
Huergo, Jennifer, National Institute of Standards and Technology
Hughes, Shawn, Utah Associated Municipal Power Systems/ Carbon Free Power Project
Huh, Ye K.
Humbird, Kelli, Lawrence Livermore National Laboratory
Hume, Seonaid C., University of Strathclyde (U.K.)
Hunnewell, Scott W., Tennessee Valley Authority
Hurt, Nathan H.
Hyer, Holden, Oak Ridge National Laboratory

Ibarra, Victor, Jr., Nuclear Innovation Alliance
Ickes, Michael R., Westinghouse Electric Company
Isbell, Douglas, NASA Jet Propulsion Laboratory

Jasper, Heiko, Framatome (France)
Jiao, Anjun, Palo Verde Nuclear Generating Station
Jin, Mia, Pennsylvania State University

Joe, Jeffrey C., Idaho National Laboratory
Johnson, Amanda, MPR Associates
Johnston, Kimberly, Ernst & Young
Jokisaari, Andrea, Idaho National Laboratory
Jones-McCall, Candi, Duke Energy
Jordan, Tyson, Oak Ridge National Laboratory

Kanzaki, Yurugi, Mitsubishi Heavy Industries (Japan)
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Keller, Michael F., Hybrid Power Technologies
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Kim, Hyeong-Seog, KEPCO Nuclear Fuel Company (South Korea)
Kim, Hyosim, Los Alamos National Laboratory
Kim, Ji Yong, Ulsan National Institute of Science and Technology (South Korea)
Kim, Karen S., Electric Power Research Institute
Kim, Kyung M., Seoul National University (South Korea)
Kim, Sang Ji, Korea Atomic Energy Research Institute (South Korea)
King, Mike, Nuclear Regulatory Commission
Kinley, Marsha, Duke Energy
Klinvex, Alicia M., Naval Nuclear Laboratory
Kos, Bor, Oak Ridge National Laboratory
Koskinen, Hanna M., VTT Technical Research Centre of Finland
Kovesdi, Casey R., Idaho National Laboratory
Krause, Wolfgang, Framatome (France)
Kropp, Garrett, U.S. Department of Energy
Kucinski, Nicholas, Oak Ridge National Laboratory
Kwon, Inyong, Korean Atomic Energy Research Institute (South Korea)
Kwon, Sungju, KEPCO Nuclear Fuel (South Korea)
Kwon, Youngmin, KEPCO Nuclear Fuel (South Korea)

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Lee, Han G., Seoul National University
Lee, Joomyung, North Carolina State University
Lee, Minho, Ulsan National Institute of Science and Technology (South Korea)
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Lv, Sophie

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Miedl, Horst, TÜV Rheinland Industrie Service (Germany)
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Nicholson, Scott J.
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Nusspickel, Stephen, Nuclear Electric Insurance Limited

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Robbins, Peter, NextEra Energy
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Schneibel, Andrea, Oak Ridge National Laboratory
Scott, Jonathan, Idaho State University

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Shah, Sandeep
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Shi, Anna
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Smith, Kurt, Oak Ridge National Laboratory
Snow, Elizabeth, Meridian Services Group
Song, Rongjie, Idaho National Laboratory
Sowers, George, Colorado School of Mines
Sowinski, Thomas
Spalding, Chad, Enercon
Spielman, Zachary, Idaho National Laboratory
Stamatakos, John A., Southwest Research Institute
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Thompson, Tracy, UT-Battelle
Tildesley, David, Atomic Weapons Establishment (U.K.)
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Tran, Anson, MPR Associates
Travis, Joy, Duke Energy
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Trotta, Richard, Holtec International
Tumlinson, Rick
Tweedle, Tom, Westinghouse Electric Company

Underwood, Teresa, Magnus & Company

Vandenkieboom, John, Los Alamos National Laboratory
Vereshchaka, Aleksandr, NRC Kurchatov Institute (Russia)
Verma, Kamal, Laurentis Energy Partners & Canadian Nuclear Partners (Canada)
Vogel, Sven C., Los Alamos National Laboratory
VonNida, Jason, Curtiss-Wright
Wachs, Daniel M., Idaho National Laboratory
Wacker, John, Pacific Northwest National Laboratory
Walker, Trent
Wallace, Christopher J., University of Strathclyde (U.K.)
Wang, Tianhao, Pacific Northwest National Laboratory
Wang, Yachun, Idaho National Laboratory
Ward, Caleb, U.S. Nuclear Industry Council
Warren, Jadan, Duke Energy
Waters, Michael, U.S. Nuclear Regulatory Commission
Watkins, James
Weaver, W.
Webber, Michael E., University of Texas–Austin
Weber, Loree, KeySource Thomas Thor
Weidenauer, Patrick, Framatome GmbH (Germany)
Weinmeister, Teresa
Wellman, Dawn M., Pacific Northwest National Laboratory
Werden, Jesse W., Oak Ridge National Laboratory
White, Morgan C., Los Alamos National Laboratory
Whitehurst, Michael, Centrus Energy
Wilbanks, Brock, Southern Nuclear
Wilcken, Brian M., Idaho National Laboratory
Williams, Steven, Electric Power Research Institute
Wilson, George, TerraPower
Wilson, Jarod C., Massachusetts Institute of Technology/ Nuclear Reactor Laboratory
Winch, Nicola, Los Alamos National Laboratory
Woo, Tae H., Cyber University of Korea (South Korea)
Wright, Adam
Wynn, Jackson, Mitre Corporation

Xing, Jinding
Xu, George, Canadian Nuclear Laboratories (Canada)
Xu, Jim, Nuclear Regulatory Commission
Xu, Ning, National Nuclear Security Administration's Office of International Nuclear Safeguards
Xu, Xinyuan, Pennsylvania State University

Yan, Jay
Yoon, Jooil, KEPCO Nuclear Fuel Company (South Korea)
Yoon, Seokjoo
Yu, Jiankai, Massachusetts Institute of Technology
Yu, Xiao-Ying, Pacific Northwest National Laboratory

Zahur, Awais, Ulsan National Institute of Science and Technology (South Korea)
Zhang, Deanna, Nuclear Regulatory Commission

STUDENT MEMBERS

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Maestas, Michael M.

Brigham Young University
Bolander, Ara
Larson, Spencer C.
Ruth, Ryan J.

Columbia University
Liu, Jonathan

Excelsior College
Almanza Rivera, Favio
Giles, Bailey S.
Koshowsky, Richard S.
Mason, Frank
Propst, Theodore J.
Stone, Sarah M.
Westermann, Budd R.

Georgia Tech Research Institute
Atchley, Howard T.-B.

Idaho State University
Grubbs, Jeremiah

Indian Institute of Technology (India)
Aradhyam, Rishabh
Singh, Parth

Kennesaw State University
Estrada, Benjamin L.
Schneider, Christian M.

Massachusetts Institute of Technology
Edwards, Alexander T.
O'Brien, Alexander D.

Missouri University of Science and Technology
Lutz, Elijah C.

Nagoya University (Japan)
Fukui, Yuhei
Ito, Kaito
Ito, Masato
Morishita, Yuki
Yamaguchi, Hibiki

North Carolina State University
Taylor, Andrew J.

Thomas Edison State College
Sutton, Nicholas A.

University of Louisville
Hartman, Natalie K.

University of Massachusetts Lowell
Kemper, Nikolaus R.

University of Michigan–Ann Arbor
Evans, Carly E.

University of Nevada–Las Vegas
Libero, Josephine A.

University of Notre Dame
Poole, Nicholas A.

University of Strathclyde (U.K.)
Branikas, Efstathios

University of Tennessee–Knoxville
Coll, Rory M.
Dye, Gregory T.
Hyslop, Hannah M.
Pathirana, Visura
Watson, Gabriel W.

University of Texas–San Antonio
Cavazos, Steven J.

Utah State University
Bryan, Jacob A.

Valparaiso University
Scheel, Lane M.

Institution not provided
Gettelfinger, Gabriel H.
Good, Nicole

Check out the new and improved ANS Career Finder!

Recently redesigned and renamed, ANS Career Finder is an online forum connecting utilities, vendors, national labs, government agencies, and academic institutions with our qualified talent pool of nuclear science and technology professionals.

Whether you're looking for career opportunities in the nuclear field or are looking to fill an open position, look no further than the Career Finder.

American Nuclear Society
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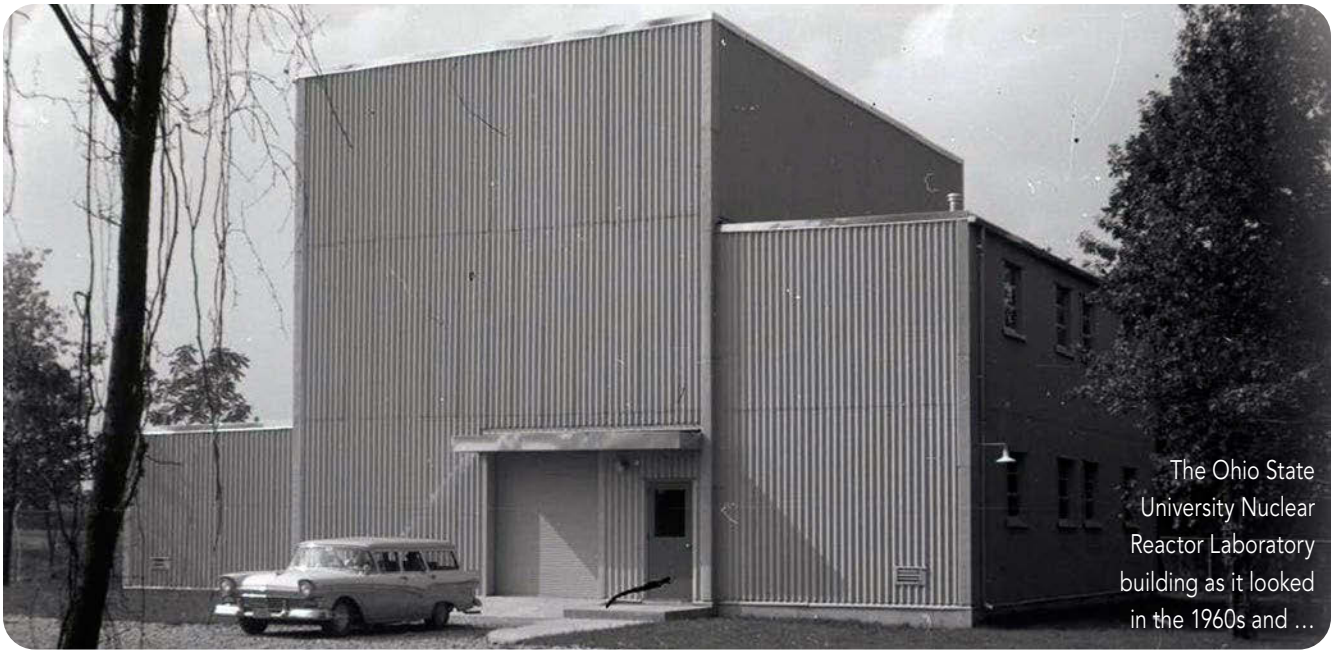

The Ohio State University Nuclear Reactor Laboratory building as it looked in the 1960s and …

Ohio State Nuclear Reactor Lab celebrates 60 years of research, education, and service

By OSU College of Engineering and Nuclear Reactor Laboratory Staff

Ohio State University's Nuclear Reactor Laboratory was built in 1960 with the help of a $217,100 grant from the Atomic Energy Commission to establish a small-scale research reactor. The reactor first went critical on March 6, 1961. This year, the NRL celebrates the 60th anniversary of its initial criticality.

The Ohio State reactor is the only research reactor in Ohio and one of just 24 research reactors located on a U.S. college campus. In its early years, the reactor used high-enriched uranium fuel. In 1988, the reactor converted its fuel source, becoming only the second reactor in the United States to use proliferation-proof low-enriched uranium fuel. In 1992, the reactor was upgraded from its original 10-kilowatt capability to 500 kilowatts.

"What started as a 10-kilowatt training reactor is now the only operating research reactor in the state of Ohio," said Dorota Grejner-Brzezinska, Ohio State's interim vice president for knowledge enterprise. "NRL continues to be a vital technical and physical asset, providing services to allow advancement in materials, medicine, manufacturing, and nuclear technology–related industries, not only in Ohio, but nationally."

The mission of the NRL is to serve as a nuclear radiation user facility for students, faculty, and external researchers and as a teaching facility for nuclear engineering education.

"Numerous Ohio State nuclear engineering graduate students have utilized the reactor for their thesis and dissertation projects over the years," said NRL director Lei Raymond Cao. "Use of the

... how it looks today. (Photos: Ohio State University Nuclear Reactor Laboratory)

research reactor is crucial for gaining hands-on experience in nuclear engineering. This is reflected in the number of graduates who have engaged in research utilizing the reactor and gone on to work at national laboratories where this experience is highly valued."

The NRL has been home to many sensor studies conducted by faculty members, beginning with Prof. Don Miller (ANS past president, 1996–1997) in the 1980s and 1990s and continuing currently in the nuclear engineering program. These studies have been funded by the Department of Energy to advance state-of-the-art reactor instrumentation.

With unique capabilities such as near-core large experiment irradiation, *in situ* or *ex situ* sensor evaluation under high temperature, high radiation dose, and flexible operations, the NRL has become a facility not only for university researchers, but for those in industry who utilize the capabilities of the reactor lab.

In recent years, the NRL has continued to expand its capabilities, adding the ability to conduct neutron beam experiments such as thermal neutron imaging, fast neutron tomography, and high-temperature experiments. In 2017, the NRL became a partner facility of the DOE's Nuclear Science User Facilities program, expanding access to new researchers from across the country.

"Some of the nation's most distinguished nuclear industry and government leaders have been trained on this reactor," said Randy Moses, senior associate vice president for research. "And research conducted at the NRL has had wide-ranging impact, from advancing new isotopes for radiation treatments to developing reliable satellite communication electronics that can withstand the harsh radiation in space."

Outside researchers who have worked with the reactor include academic institutions, national laboratories, private industry, and a federal agency. Recently, the NRL has received multiple Consolidated Innovative Nuclear Research awards and Small Business Innovation Research grants to support the outside research being conducted at the lab.

Since becoming a national user facility, the NRL has added 5,000 square feet of lab space. The NRL plans to use the space to facilitate new avenues of research. "As we expand into the new annex, the additional space will allow for more student interaction at the facility, as well as increased utilization," Cao said.

The 60th anniversary of the on-campus research reactor is a moment for the lab to celebrate its past. But like all researchers at Ohio State, those in the NRL are focused on the future. For 60 years, the Ohio State University Research Reactor has maintained excellence in education, research, and industrial service while meeting safety and regulatory obligations. The NRL aims to not only continue to meet those needs but exceed them.

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

BUSINESS DEVELOPMENTS

General Fusion to build Fusion Demonstration Plant in U.K.

The **United Kingdom Atomic Energy Authority** and **General Fusion** have announced an agreement under which General Fusion will build and operate its Fusion Demonstration Plant at UKAEA's Culham Campus. General Fusion will enter into a long-term lease with UKAEA following the construction of a new facility at Culham to host the demonstration plant.

■ **Framatome** has acquired **Valinox Nucléaire** from the Vallourec Group. Valinox is a French company that specializes in the production of seamless steam generator tubes for nuclear power plants. It will become a Framatome subsidiary but will retain its brand name.

■ **NorthStar Medical Radioisotopes** and **Clarity Pharmaceuticals** have signed a master supply agreement for the therapeutic radioisotope copper-67. Under the agreement, NorthStar will supply Cu-67 exclusively to Clarity as an active pharmaceutical ingredient used to support Clarity's Targeted Copper Theranostics programs. Cu-67 is a beta-emitting radioisotope with clinical applications as a radiopharmaceutical to directly target and deliver therapeutic doses of radiation to destroy cancer cells in patients with serious disease.

■ **EDH Nuclear Medicine and Healthcare Services** and **SHINE Medical Technologies** have entered into a distribution agreement enabling EDH to act as a SHINE-authorized distributor for selected countries. Under the agreement, EDH will sell and distribute SHINE's non-carrier-added lutetium-177, manufactured in Janesville, Wis. Lu-177 is a low-energy beta-particle emitter that works by directly irradiating cancer cells after being delivered to the cancer site by a targeting molecule.

■ **Williams Industrial Services Group**, a construction and maintenance services company, has announced that with the transfer in ownership of the Indian Point plant to **Holtec International**, the company has been granted an expansion of its nuclear decommissioning scope with Holtec from two units to five. Williams will provide supervision and skilled craft labor from the local union halls near Indian Point to support Holtec and its subsidiary, **Comprehensive Decommissioning International**, across a wide array of activities. Williams's work is expected to begin in the third quarter of 2021.

CONTRACTS

Curtiss-Wright selected to upgrade Columbia computer system

Curtiss-Wright has been awarded a contract by **Energy Northwest** to replace the existing plant process computer (PPC) system at the Columbia nuclear power plant. Under the contract, Curtiss-Wright will provide a complete equipment design and build for the PPC system upgrade, including hardware, software, and installation support services. PPC systems collect data from across the plant's operations, process the data into vital information, and display the information for plant personnel to continuously monitor and diagnose performance.

■ **SHINE Medical Technologies** has entered into a multiyear contract with the **University of Missouri Research Reactor** for the irradiation of ytterbium-176, the starting material for the production of lutetium-177, a therapeutic isotope showing great promise for improving patient outcomes for a range of cancers. Energy from Lu-177 travels only a short distance once it reaches cancer cells, enabling the isotope to destroy those cells with little damage to surrounding tissue.

ADVANCED REACTOR MARKETPLACE

NuScale Power secures investment for SMR deployment from IHI

NuScale Power announced on May 26 that it has finalized an investment agreement with **IHI**, a comprehensive heavy-industry engineering and manufacturing company headquartered in Japan. As part of a commercial relationship with NuScale, IHI will provide a cash investment in NuScale Power. The IHI-NuScale relationship results in IHI becoming a strategic supplier for NuScale plants, thereby becoming a preferred supplier of certain manufactured components for NuScale plants globally. This is the second commercial relationship and investment in NuScale Power from a Japanese-based company, following the recent agreement with **JGC Holdings Corporation**.

■ **Hayward Tyler** recently shipped four high-temperature molten salt pumps destined for the Integrated Effects Test (IET) facility under development by **Southern Company** and **TerraPower** to advance the development of the molten chloride fast reactor (MCFR), a transformational, fourth-generation, molten salt nuclear technology designed to enable low-cost, economy-wide decarbonization. Located at TerraPower's Everett, Wash., facility, the IET is a nonnuclear, externally heated multi-loop system intended to validate integrated operation of MCFR systems, as well as to demonstrate multiple auxiliary MCFR functions.

Standards

Approved

The following standard has been approved:

■ ANSI/ANS-10.4-2008 (R2021), *Verification and Validation of Non-Safety-Related Scientific and Engineering Computer Programs for the Nuclear Industry* (reaffirmation of ANSI/ANS-10.4-2008 [R2016]).

This standard provides requirements and guidelines for the verification and validation of non-safety-related scientific analysis and engineering computer programs developed for use by the nuclear industry. The scope is restricted to research, analysis, engineering, and other non-safety-related applications. This standard also excludes computer programs developed for non-safety-related digital control systems.

Comments requested

Comments are requested on the following standard by July 16, 2021:

■ ANS-8.12-1987 (R202x), *Nuclear Criticality Control and Safety of Plutonium-Uranium Fuel Mixtures Outside Reactors* (reaffirmation of ANSI/ANS-8.12-1987 [R2016]).

This standard provides guidance for operations with plutonium-uranium oxide fuel mixtures outside nuclear reactors. The principal objective of this standard is to provide subcritical configuration data for mixed oxide fuel for various isotopic compositions and powder/pellet densities.

Comments are requested on the following standard by July 19, 2021:

■ ANS-10.5-2006 (R202x), *Accommodating User Needs in Scientific and Engineering Computer Software Development* (reaffirmation of ANSI/ANS-10.5-2006 [R2016]).

This standard presents criteria for accommodating user needs in the preparation of computer software for scientific and engineering applications.

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

Volunteer support needed

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

■ ANS-2.17, *Evaluation of Subsurface Radionuclide Transport at Commercial Nuclear Power Plants* (revision of ANS-2.17-2010 [R2016]).

■ ANS-2.18, *Standards for Evaluating Radionuclide Transport in Surface Water for Nuclear Power Sites* (proposed new standard).

■ ANS-3.2, *Managerial, Administrative, and Quality Assurance Controls for the Operational Phase of Nuclear Power Plants* (revision of ANSI/ANS-3.2-2012 [R2017]).

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

■ ANS-3.13, *Nuclear Facility Reliability Assurance Program (RAP) Development* (proposed new standard).

■ ANS-53.1, *Nuclear Safety Design Process for Modular Helium-Cooled Reactor Plants* (revision of ANSI/ANS-53.1-2011 [R2016]).

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

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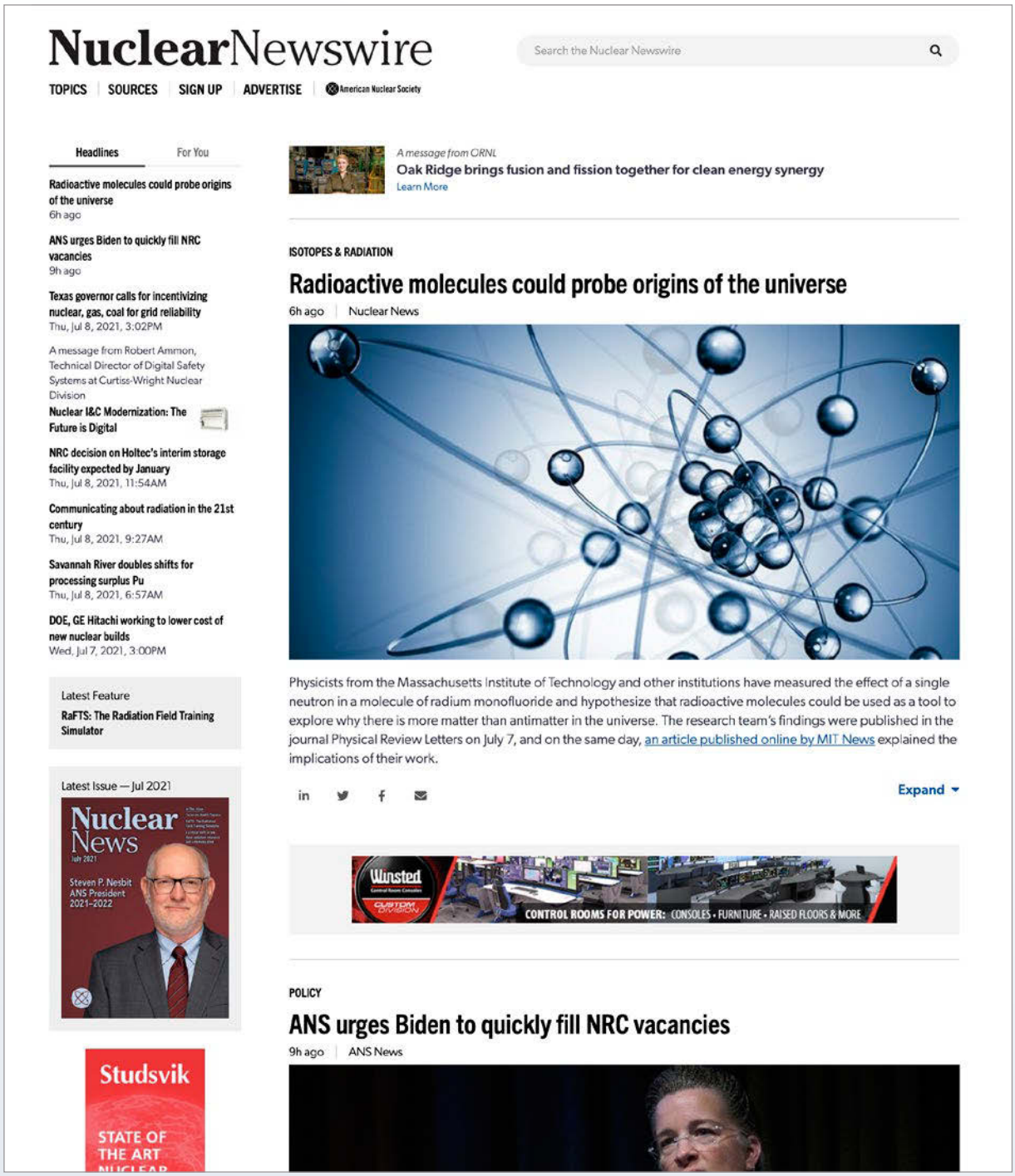

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ANS

Putting climate change into perspective

By James Conca

During the American Nuclear Society's Annual Meeting in June, the President's Special Session (see page 28) featured a particularly good discussion between Michael Shellenberger, president of research and policy organization Environmental Progress and author of *Apocalypse Never: Why Environmental Alarmism Hurts Us All*, and Mark Mills, a senior fellow at the Manhattan Institute and a faculty fellow at Northwestern University's McCormick School of Engineering and Applied Science. The theme of the session was "CE^{3}D (seed): Clean Energy for Everyone, Everywhere, on Demand."

ANS President Mary Lou Dunzik-Gougar introduced the pair with a short statement on the conundrum between energy and the quality and safety of human life. Many world leaders are calling for a phaseout of fossil fuels in favor of intermittent electricity generation such as wind and solar to achieve a carbon-free energy future.

At the same time, access to energy is the first and dominant factor in the equation of human happiness. This concept is embodied in the United Nations' Human Development Index (HDI), the relationship between per capita energy use and quality of life. The relationship plots HDI values (between 0, where life is absolutely hell, and 1, where life is as good as it can get) against per capita energy use for every country in the world. The developed world is about 0.9, with per capita energy use between 6,000 and 16,000 kilowatt-hours per year. The poorest countries are between 0.4 and 0.6, with per capita energy use between 500 and 2,000 kWh/yr.

Since it takes about 3,000 kWh/yr to lift someone up out of poverty and up to 0.8 HDI, and 3 billion more people will be born before 2050, we will have to generate even more energy than most people are aware, at least 35 trillion kWh/yr.

As Dunzik-Gougar points out, political leaders are talking more and more about pairing nuclear power with wind and solar, while phasing out fossil fuels, for a carbon-free energy future that will mitigate the worst effects of global warming. But is that the right goal?

According to the OFRA/CRED International Disaster Database, climate-related deaths have declined tenfold over the past 100 years, mainly in countries with sufficient energy to build resilient structures and to enable immediate medical response when disasters strike, followed by a robust economic recovery.

So it may be more appropriate to shift the focus from reducing energy consumption to addressing the needs of billions of people who, for lack of cheap and reliable fuels, are the most vulnerable. Especially since there is little chance that we will achieve our climate goals in time to matter. Just look at the International Energy Agency's latest report, *Net Zero by 2050*, on that.

Our standard of living increased dramatically with the use of energy-dense fossil fuels that powered the industrial revolution. We need to take the next step toward emission-free nuclear, the most energy-dense and reliable fuel available.

Shellenberger started the discussion by dialing down the climate hysteria with some much-needed perspective and data. Acknowledging that global warming is real and needs to be addressed, he cast doubts on the ideology that it is an existential threat to the world and that only by attaining net-zero carbon emissions globally can we save the world. Indeed, the data do not support such a claim.

We are not, as many claim, in a mass extinction. The International Union for the Conservation of Nature estimates that only 0.8 percent of the 112,000 species on earth within its database have gone extinct since 1500, and that three-fourths of all species are not threatened.

Energy has never been cheaper in human history, and because of that, food has never been cheaper or more plentiful. We produce enough food for 10 billion people right now. Droughts are not increasing globally, and crop yields have been steadily increasing globally over the past several decades as energy input to agriculture increases.

And the amount of land needed to grow this food has steadily decreased over the past 50 years because of energy, machinery, and fertilizer. The land used to raise cattle for meat and dairy has also decreased as practices have improved. In fact, less productive agricultural lands have gone fallow in places like Europe and have turned back into forest and steppe in large amounts. But energy-poor countries still use too much land to grow their food, because they are energy poor.

Increased energy use has decreased extreme global poverty from 44 percent to 10 percent, while life expectancy has doubled. Deaths from natural disasters have steadily dropped from 5 million per decade a hundred years ago to only 300,000 because of better management practices. But again, energy-poor countries still struggle.

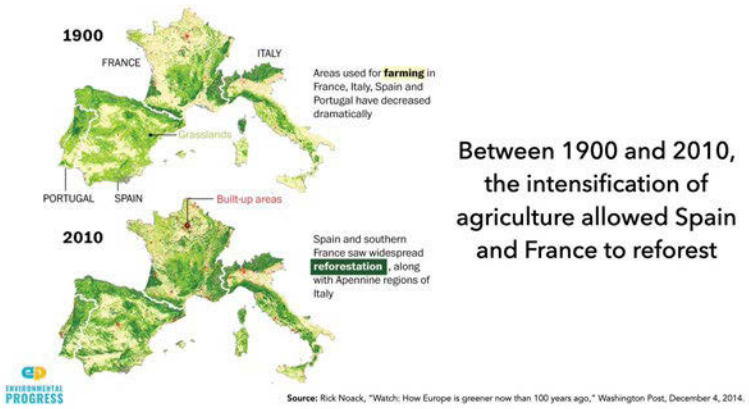
Nowhere is misplaced blame so blatant as with wildfires, especially in California. The number of wildfires has not increased over time. But bad forest management has caused an increase in fuel, and together with encroaching development, has increased the number of ignitions, fire intensity, and the amount of property damage that is occurring. Well-managed forests do not exhibit this problem.

As the main advisor to Bill Gates has said, wars, disease, volcanoes, and tsunamis, not climate change, pose the highest risk of catastrophe.

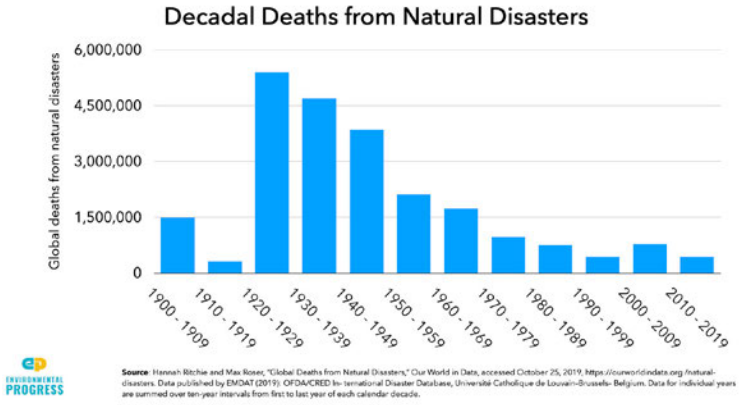
Shellenberger talked about many other things, and I encourage you all to watch the discussion available through the ANS Meetings archives.

Mark Mills took over the discussion by talking about energy technologies. He began by showing that global energy went from 95 percent renewable in 1800 to only about 10 percent today. To imagine that we can reverse that in 20 or 30 years is pretty unrealistic. Not just that, but all the countries that pledged action at the Paris climate conference have failed to keep their promises, with the exception of two–Gambia and Morocco. That is not the global teamwork needed for success.

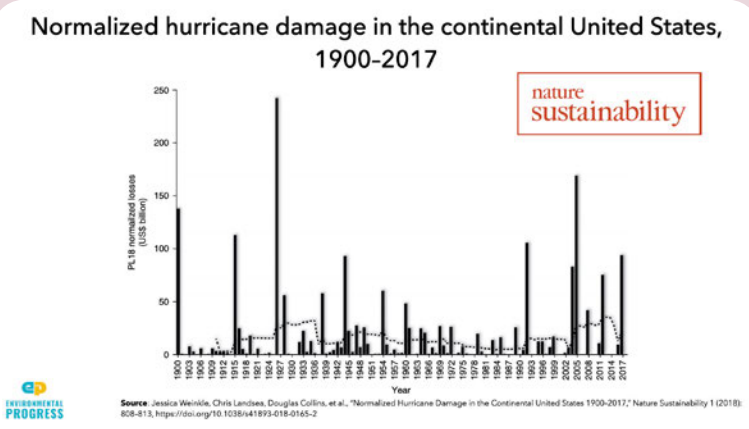
Opinion continues



Progress in agricultural practices has lowered the amount of land used to grow our food, so much so that previous farmlands are reforesting. We have to make sure developing countries have these practices and the machinery and energy to do the same. (Figure: Environmental Progress)



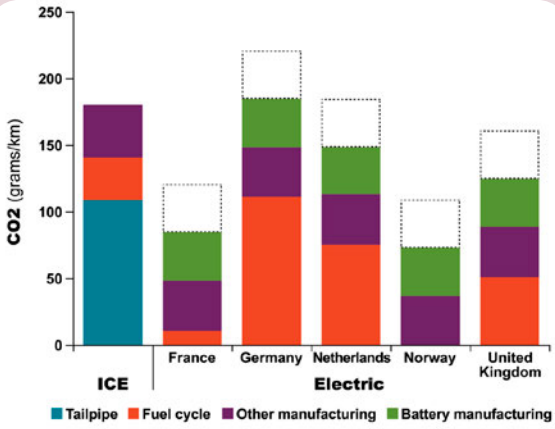
Regardless of the number of natural disasters like hurricanes, we are getting better at not dying from them, even in the developing world. It takes planning and energy. (Figure: Environmental Progress)



Again, regardless of the number of hurricanes, we are getting better at minimizing the damage from them, especially considering that today, many more people live in the high-risk zones. (Figure: Environmental Progress)

Not just that, but after the better part of a trillion dollars has been spent on wind and solar, they don't provide even 10 percent of the world's energy.

The hope that electric vehicles will wean us off petroleum is falling just as short. There are fewer than 10 million electric vehicles in the world, and the Energy Information Administration thinks that number will double or triple by 2030. Some believe it will rise to 300 million. Unfortunately, the number needs to be over a billion to make a significant dent in petroleum use. Since there will be 3 billion internal combustion engine vehicles by 2040, even this wildly optimistic number will not get us to decarbonization.



The life-cycle CO_2 emissions for electric vehicles are not necessarily much lower than for internal combustion engines when manufacturing and materials are factored in. (Figure: Mark Mills, Senior Fellow, Manhattan Institute)

The amount of critical minerals required for any of this is enormous. An electric vehicle requires three to six times the amount of critical minerals like lithium, cobalt, manganese, copper, and even aluminum. The financial and environmental effects are enormous. But a truly surprising bit of information is that the life-cycle CO_2 emissions of electric vehicles are not that much lower than that for internal combustion engines.

Making the electricity to fuel the electric vehicle, making the car itself, and making the batteries emits almost as much CO_2 as an internal combustion engine, although it depends greatly on how the electricity is generated. In France, the amount of nuclear generated means an electric vehicle is responsible for significantly less CO_2 than an internal combustion engine, although still only about half, while in Germany, an electric vehicle's carbon footprint is actually a little more than that for an internal combustion engine vehicle.

It is similar for renewable energy sources. The basic materials such as steel, concrete, and glass needed to build solar and wind generators is 10 to 100 times greater than that required for gas, nuclear, and coal, and very energy intensive to produce. That's not important when penetration is less than 10 percent, but very important when it gets to the 50 percent level discussed for many decarbonization scenarios like those from the IEA report mentioned earlier.

For batteries themselves for storing grid-scale amounts of power, there is physically no way to produce the amount of critical minerals, and build the volume of batteries needed, to support the grid. If we try, the amount of materials moved to extract these minerals will exceed the movement of all other materials by humans combined. None of the miners and mining companies of the world are planning to expand production to even begin to meet these needs. In fact, mining is decreasing.

All this means is that while batteries will supply significant energy to society, we will never have a grid dominated by batteries. We will never have cars dominated by batteries. It is why jumbo jets will never fly on batteries. And it is why oil demand will still go up, even with a significant number of battery-powered vehicles.

Mills's parting comment was this: "The only way to offset humanity's insatiable appetite for hydrocarbons, with everything else than can be switched to electricity, will not be to use more wind and solar, but to use more nuclear plants."

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

Womack

Chris Womack has been named chairman and chief executive officer of Georgia Power, in addition to his role as president, which he has held since November 2020. He succeeds Paul Bowers, who retired as chairman and CEO on June 1. Womack joined Southern Company in 1988 and has held several leadership positions within the company and its subsidiaries, serving as executive vice president of external affairs at Georgia Power and senior vice president and senior production officer of Southern Company Generation.

Silex Systems and Cameco Corporation have announced the appointment of **James Dobchuk** as president and chief commercial officer of Global Laser Enrichment. Dobchuk has over 20 years of experience in global uranium marketing and sales, including seven years as president of Cameco's U.S. subsidiary, Cameco Inc. Most recently, he served as an executive director responsible for supporting Cameco's U.S.-focused commercial interests and directing its government affairs activities in Washington, D.C.

Gerard M. "Gerry" Anderson, executive chairman of Detroit-based DTE Energy, has been elected

Anderson

chairman of the board of the Edison Electric Institute (EEI), the national association of investor-owned electric companies. Also elected were two vice chairmen: **Warner Baxter**, chairman, president, and chief executive officer of St. Louis–based Ameren Corporation, and **Pedro J. Pizarro**, president and CEO of Rosemead, Calif.–based Edison International. The EEI chairmanship rotates on an annual basis, and Anderson succeeds Ben Fowke, chairman and CEO of Minneapolis-based Xcel Energy.

Baxter

Pizarro

Herman

ValvTechnologies has named **Juliana Herman** as its global marketing director. Herman is responsible for the development and deployment of ValvTechnologies' marketing strategy, product and brand management, marketing programs, communication campaigns, and market analysis on a global basis. She previously served as senior product marketing manager for Emerson.

Kowalik

Westinghouse Electric Company has appointed **Miroslaw Kowalik** president of Westinghouse Poland, where he will lead the company's plans to invest in nuclear technologies in that country. He most recently served as president of Enea, one of the largest energy companies in Poland, and has held senior leadership positions at SNC-Lavalin, Alstom, and ABB.

England

Moltex Energy has named **Michael England** as chief operating officer. England is responsible for leading the day-to-day operations of the company, including overseeing the development of the Stable Salt Reactor–Wasteburner and Waste to Stable Salt technologies. He previously worked for Ontario Power Generation, where he held senior management roles in corporate

People continues

strategy, finance, commercial management, project assurance, and nuclear decommissioning.

The Nuclear Regulatory Commission recently named new senior resident inspectors at three nuclear plants. **Matt Endress** was selected as the

Endress

senior resident inspector at the Turkey Point plant, near Homestead, Fla. Endress joined the NRC in 2011 as a reactor engineer in the Division of Reactor Safety in the NRC's Region II office in Atlanta. He most recently served as the senior resident inspector at the Vogtle plant, in Waynesboro, Ga. **Phil Niebaum**

Niebaum

was chosen as the new senior resident inspector at the Columbia plant, near Richland, Wash. He joined the NRC in 2006 as a project engineer in the Region II office. He most recently served as the senior resident inspector at the Farley plant, near Columbia, Ala. **Dan Orr** was

Orr

picked as the senior resident inspector at the St. Lucie plant, near Port St. Lucie, Fla. Orr joined the NRC in 1997 and most recently served as the senior resident inspector at Turkey Point.

Kudos

Jovica Riznic, ANS member since

Riznic

2000 and technical specialist with the Canadian Nuclear Safety Commission, has been named the 2021 recipient of the George Westinghouse Gold Medal from the American Society of Mechanical Engineers. The award recognizes eminent achievement or distinguished service in the power field of mechanical engineering. Riznic works on regulatory analysis and assessment of technical issues with operating nuclear power plants. Currently, he leads research teams providing Canadian contributions to numerous international research projects with the U.S. Nuclear Regulatory Commission, the OECD Nuclear Energy Agency, and the International Atomic Energy Agency.

Rian Bahran, ANS member since 2004 and a Los Alamos National

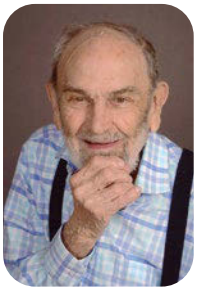
Bahran

Laboratory scientist on assignment in Washington, D.C., has received the Secretary of Defense Medal for Exceptional Public Service. Bahran was recognized for his service and contributions as a senior science and policy advisor for nuclear deterrence policy from January 2019 to May 2020 and a special assistant to the undersecretary of defense for policy from May 2020 to June 2021. He also led various national and international forums related to the technical aspects of U.S. extended deterrence to the North Atlantic Treaty Organization and served as the Department of Defense policy lead for the successful negotiation of a nuclear accident-incident agreement.

Shriver

Forrest Shriver, ANS member since 2016, was one of six science and technology innovators from across the United States who recently joined the fifth cohort of Oak Ridge National Laboratory's Innovation Crossroads program, which provides support to science-based startups to help advance technologies from the laboratory to the marketplace. Shriver has developed a continuous, automatic learning system for building asset-specific operational databases. The technology performs collection and summarization of high-throughput data sources that remain robust under variable conditions. The secure system also removes the need for manually supervised data collection and is anticipated to be scalable and deployable across diverse industries. Innovators receive a two-year fellowship that provides a cost-of-living stipend, comprehensive business development plan assistance, and up to $200,000 toward collaborative R&D at ORNL.

Obituaries



Kenneth E. Roach, 91, ANS member since 1960; received a bachelor's degree in physics from Lynchburg College in 1956; worked for Babcock & Wilcox from 1955 to 1963; co-founded Southern Nuclear Engineering in 1964, serving as director and vice president; while there, conceived the idea and managed the project that produced the first plutonium-238 in a commercial reactor as a by-product of reactor operations; from 1973 to 1977, was an executive scientist with NUS Corporation, where he marketed and managed research and development contracts; projects included classified work for the U.S. Air Force, a study of the relative merits of several fuel cycles and their effect on nuclear proliferation, and an investigation of the feasibility of the tandem fuel flow concept for the U.S. State Department's Arms Control and Disarmament Agency; founder and director of Southern Science Applications, which later became a regional office of Black & Veatch; died June 20, 2020.

Roach

Russell B. Starkey Jr., 78, ANS member since 1983; held several management positions with Carolina Power & Light Company (CP&L), including general manager of the Robinson plant, vice president of the Brunswick plant, and ultimately vice president of nuclear services for all of CP&L's nuclear plants; later moved to United States Enrichment Corporation (USEC), a subsidiary of Centrus Energy, where he served as general manager of USEC's uranium enrichment plant in Paducah, Ky., before assuming the position of vice president of operations in 2005; became vice president of USEC's American Centrifuge in 2008; retired in 2010; died May 16, 2021.

Starkey

Direct Answer

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Calendar

● First time listed or significant change made
✖ Meeting canceled or postponed; see listing for details

●■✖ ANS event
●■✖ Non-ANS event cosponsored by ANS

August

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

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

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

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

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

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

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

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

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

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

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

September

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Calendar continues

ANS Winter Meeting & Expo

November 30 – December 3, 2021
Washington Hilton
Washington, D.C.

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Embedded Topical Meetings

Decommissioning Environmental Science and Remote Technology 2021
November 30 – December 4

14th International Topical Meeting on Nuclear Applications of Accelerators
November 30 – December 4

- Sep. 27–28—**2nd International Conference of Materials, Chemistry and Fitness-for-Service Solutions for Nuclear Systems (MCFD 2021)**, virtual meeting. cns-snc.ca/events/mcfd2021/
  Meeting has been rescheduled to October 14–15

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

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

- Sep. 28–29—**Enlit Asia**, virtual meeting. enlit-asia.com/

October

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

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

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

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

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

- Oct. 14–15—**2nd International Conference of Materials, Chemistry and Fitness-for-Service Solutions for Nuclear Systems (MCFD 2021)**, virtual meeting. cns-snc.ca/events/mcfd2021/

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

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

  Oct. 17–21—**2021 Test, Research and Training Reactors (TRTR) Annual Conference**, Raleigh, N.C. projects.ncsu.edu/mckimmon/cpe/opd/trtr/

  Oct. 18–21—**Experience POWER**, San Antonio, Texas. experience-power.com/

  Oct. 24–28—**TopFuel 2021**, Santander, Spain. euronuclear.org/topfuel2021

  Oct. 25–29—**Technical Meeting on Artificial Intelligence for Nuclear Technology and Applications**, virtual event. iaea.org/events/evt2004304

  Oct. 27–28—**All-Energy Australia**, Melbourne, Australia. all-energy.com.au/en-gb.html

  Oct. 27–29—**POWERGEN India**, New Delhi, India. powergen-india.com/

November

- Nov. 7–12—**2021 International Topical Meeting on Probabilistic Safety Assessment and Analysis (PSA 2021)**, Columbus, Ohio. psa.ans.org/2021

  Nov. 8–12—**International Conference on a Decade of Progress after Fukushima-Daiichi: Building on the Lessons Learned to Further Strengthen Nuclear Safety**, Vienna, Austria. iaea.org/events/international-conference-on-a-decade-of-progress-after-fukushima-daiichi-building-on-the-lessons-learned-to-further-strengthen-nuclear-safety-2021

  Nov. 14–21—**FUSION20**, Shizuoka City, Japan. asrc.jaea.go.jp/soshiki/gr/HENS-gr/fusion20/index.html

  Nov. 15–17—**NESTet 2021—Nuclear Education & Training Conference**, Brussels, Belgium. ens.eventsair.com/nuclear-education-and-training/

  Nov. 30–Dec. 2—**Enlit Europe**, Milan, Italy. enlit-europe.com/live

  Nov. 30–Dec. 2—**World Nuclear Exhibition**, Paris, France. world-nuclear-exhibition.com/

- Nov. 30–Dec. 4—**2021 ANS Winter Meeting and Technology Expo**, Washington, D.C. ans.org/meetings/wm2021/

December

Dec. 1–3—**Perma-Fix 18th Annual Nuclear Waste Management Forum**, Nashville, Tenn. ir.perma-fix.com/upcoming-events/detail/824/perma-fixs-18th-annual-nuclear-waste-management-forum

Dec. 12–16—**23rd IEEE Pulsed Power Conference (PPC) and the 29th IEEE Symposium on Fusion Engineering (SOFE)**, Denver, Colo. uta.engineering/ppcsofe2021/

January 2022

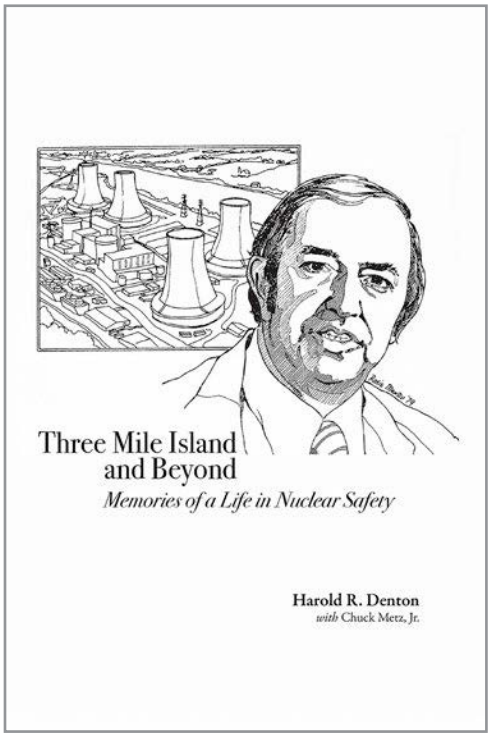
Jan. 11–13—**IGD-TP Symposium and Webinar: The Role of Optimisation in Radioactive Waste Geological Disposal Programmes**, Zurich, Switzerland. igdtp.eu/event/igd-tp-symposium/

Jan. 25–27—**19th Annual USA Supply Chain Winter Conference**, Rancho Mirage, Calif. usainc.org/winter-conference/

Jan. 26–28—**PowerGen International**, Dallas, Texas. powergen.com/welcome

February

- Feb. 8–9—**International Conference on Clean Energy Technologies and Power Issues (ICCETPI 2022)**, Lisbon, Portugal. waset.org/clean-energy-technologies-and-power-issues-conference-in-february-2022-in-lisbon
- Feb. 20–24—**IRPA North American Regional Congress**, St. Louis, Mo. burkclients.com/hps/2022IRPA/site/
- Feb. 23–24—**8th Nuclear Decommissioning and Waste Management Summit**, London, U.K. wplgroup.com/aci/event/nuclear-decommissioning-waste-management-summit/
- Feb. 27–Mar. 3—**TMS 2022 Annual Meeting & Exhibition**, Anaheim, Calif. htms.org/AnnualMeeting/TMS2022



Three Mile Island and Beyond: Memories of a Life in Nuclear Safety

By Harold Denton with Chuck Metz Jr.

Book review by Roger J. Mattson

Harold Denton, in tandem with writer Chuck Metz Jr., has produced a thoughtful and informative memoir covering the high points of his notable career in nuclear safety, starting with his response to the core melt event at Three Mile Island (TMI) in 1979. Harold was catapulted to overnight fame when President Jimmy Carter selected him, without their having met, to serve as the public communicator during this first serious incident for America's commercial nuclear power program. As described in the *Washington Post* at the time of Harold's death in 2017, he was "a once-obscure federal regulator who went on to be hailed as a hero for his calm leadership and technical mastery during the most serious nuclear power accident in the country's history."

Harold was my boss from 1978 until 1984, and we stayed friends after our federal service. Thus, I can vouch for the accuracy of his recollections about TMI and the results of the research he splendidly recounts in his memoir. Writing in the first person, Harold takes us into the firestorm that engulfed him in the weeks of the incident and his overseeing of the TMI recovery efforts while taking time each day to inform residents in the region—and people around the world—about what was happening. He said his phlegmatic personality served him well in that extended effort of crisis management. I would say it a bit differently. He was the right person for the job because of his technical ability, his homey demeanor, and his calm response when things went wrong. And the locals loved him. As one contemporaneous T-shirt proclaimed, "Harold Denton can melt my core anytime."

A North Carolina native, Harold describes his roots, his upbringing, and the career path that took him to the position of director of nuclear reactor regulation at the Nuclear Regulatory Commission at the time of TMI. He attributes his calm demeanor in times of adversity to his emotional response to the death of his mother when he was 11 years old. He describes how public safety was always foremost in his work—his bottom line in his professional activities. He enlivens his book with excerpts from the letters he received from children and their parents in the region of TMI. They tell of how his leadership relieved their anxiety over the disaster unfolding within the plant and his truthful reassurance that only insignificant amounts of radiation were released to the environment.

Of course, the infamous hydrogen bubble is a centerpiece of Harold's recollection of the myriad things we dealt with at TMI. As I recall, the situation was more complex than he describes, but the disastrous effects of the hydrogen explosions at Fukushima in 2011 erased any regret NRC staffers from 1979 might have had about our treating the TMI hydrogen bubble with a measure of conservatism.

Harold intersperses his recollections of the events at TMI, Chernobyl, and Fukushima with personal and family anecdotes, many associated with his world travels as director of international programs at the NRC before his retirement and as a consultant afterward. I found his and his wife Lucinda's stories about their adventures in Russia, Cuba, and Egypt most entertaining. A word about Lucinda for those who have not met her: she is a hoot, with a wonderfully spontaneous sense of humor. In his memoir, Harold credits her wit, quick thinking, and steady advice as key factors in many of his accomplishments.

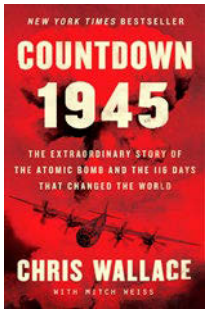
I take exception to only two things Harold recounts in his book, and I only wish I could do so in person. We would have a good discussion. The first is his statement in defense of the NRC's performance at TMI: "It was our agency that regulated the utility and was ultimately responsible for safety." Then, as today, there is wide acceptance of the premise that nuclear plant owners bear ultimate responsibility for safety, not their government regulators. My other exception is his siding with the first assessment by the International Atomic Energy Agency's advisory group, which placed primary responsibility for the Chernobyl tragedy on the reactor operators. Later investigation by Ukrainian experts led by Nikolai Steinberg reversed that assessment. The advisory group's final conclusion placed primary responsibility on a reactor design flaw hidden by the plant's Russian engineers and never communicated to the plant's operators.

In sum, I urge you to buy Harold's book. It is informative, entertaining, and an enjoyable read.

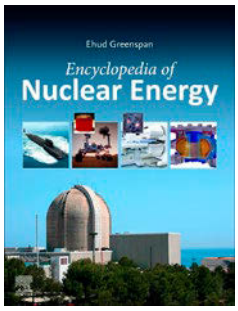
Roger J. Mattson, Ph.D., is a former NRC official, cofounder of the nuclear safety company Scientech Inc. (now a part of Curtiss-Wright), and author of Stealing the Atom Bomb *and* Spywriter.

Publications

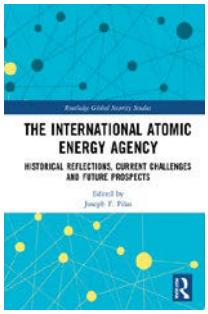
Recently Published



Countdown 1945: The Extraordinary Story of the Atomic Bomb and the 116 Days That Changed the World, by Chris Wallace with Mitch Weiss. Recently published in paperback, this book by veteran journalist and anchor of *Fox News Sunday* Chris Wallace presents a behind-the-scenes account of the 116 days leading up to the American attack on Hiroshima. Wallace takes readers inside the minds of the iconic and elusive figures who join the quest for the bomb, each for different reasons: the legendary Albert Einstein, who eventually calls his vocal support for the atomic bomb "the one great mistake in my life"; lead researcher J. Robert "Oppie" Oppenheimer and the Soviet spies who secretly infiltrate his team; the fiercely competitive pilots of the plane selected to drop the bomb; and many more. (320 pages, paperback, $17.99, ISBN 978-1-982143-35-0; order at simonandschuster.com/books)



Encyclopedia of Nuclear Energy, edited by Ehud Greenspan. This book provides a comprehensive and reliable overview of the many ways nuclear energy contributes to society. Comprising four volumes, it includes topics such as generating clean electricity; improving medical diagnostics and cancer treatment; improving crop yields; improving food shelf life; and crucially, the deployment of nuclear energy as an alternative energy source, one that is proving to be essential in the management of global warming. Carefully structured into thematic sections, this encyclopedia brings together the vast and highly diversified literature related to nuclear energy into a single resource, with convenient-to-read, cross-referenced chapters. This book will serve as an invaluable resource for researchers in the fields of energy, engineering, material science, chemistry, and physics, from both industry and academia. (3,656 pages, hardback, $2,800, ISBN 978-0-12-819725-7; order at elsevier.com/books)



The International Atomic Energy Agency: Historical Reflections, Current Challenges and Future Prospects, edited by Joseph F. Pilat. This volume offers a wide-ranging examination and discussion of the International Atomic Energy Agency's past, present, and future as it enters its seventh decade. Including contributions from leading experts across the globe, the book assesses the historical record of the IAEA, the issues and challenges it faces at present, and its future prospects. In doing so, it addresses the primary missions of the IAEA outlined in the agency's statute, i.e., to safeguard and promote the peaceful uses of nuclear energy, as well as the missions over which it is expanding its mandate, including nuclear safety and security. This book will be of interest to students of nuclear proliferation and arms control, global governance, and international security in general. (270 pages, hardback, $155, ISBN 978-0-367-74915-6; order at routledge.com)

The following are listings of the most recent issues of ANS's three technical journals. ANS members, access your free electronic subscription by visiting ans.org/pubs/journals and signing in to your ANS account.

ANS Technical Journals

FUSION SCIENCE AND TECHNOLOGY • AUGUST 2021

Neutronics Analysis of the Stellarator-Type Fusion–Fission Hybrid Reactor Using Mesh Simplification *J.-Y. Li et al.*

First-Principles Study of the Effects of Carbon, Nitrogen, and Oxygen on Helium Behavior in Body-Centered-Cubic Vanadium *R. Li et al.*

Experimental Estimation of Dust Generation Under ELM-Like Transient Heat Loads in Divertor Plasma Simulator—II *I. Park et al.*

Study on Helium Bubble Coalescence in the Slip Plane of Titanium *B. Zhang et al.*

Determination of the Oxygen Concentration in GDP Thin Films Using Rutherford Backscattering Spectroscopy *X. Ma et al.*

Influence of Gas Pressure on the Infrared Blocking Property of Ultrathin Aluminum Films on Freestanding Polyimide Substrates *Y. Liu et al.*

Research of the Characteristics of Semiconductor Bridge (SCB) Plasma *R. Wang et al.*

Calculation of Coil Currents for Equilibria with Reversed Plasma Current Density in J-Text Tokamak *Y. Chen et al.*

Multiscenario Electromagnetic Load Analysis of Blanket and VV for CFETR *J. Pan et al.*

Theoretical Study of the Impedance Matching of the Ferrite Tuner System for ICRF Heating *Q. Tan et al.*

Could Tokamaks Be the Vaccine for the Climate Change Pandemic? *E. Mazzucato*

NUCLEAR SCIENCE AND ENGINEERING • AUGUST 2021

An Analytic Benchmark for Neutron Boltzmann Transport with Downscattering—Part I: Flux and Eigenvalue Solutions *V. Sobes et al.*

An Analytic Benchmark for Neutron Boltzmann Transport with Downscattering—Part II: Flux and Eigenvalue Sensitivities to Nuclear Cross Sections and Resonance Parameters *A. Alhajri et al.*

Reactor Physics Benchmark of the First Criticality in the Molten Salt Reactor Experiment *D. Shen et al.*

Experimental Study of Air-Steam–Mixture Condensation Underneath Containment Vessel Surface *B. Tan et al.*

A Newly Developed Suppression Pool Model Based on the ISAA Code *B. Zhang et al.*

Concrete Modeling for Neutron Transport and Associated Sensitivity Studies Performed at the AMANDE-MIRCOM Facility *M. Petit*

Uncertainty Quantification of Lead and Bismuth Sample Reactivity Worth at Kyoto University Critical Assembly *C. H. Pyeon et al.*

Multilevel-in-Space-and-Energy CMFD in VERA *L. R. Cornejo et al.*

NUCLEAR TECHNOLOGY • AUGUST 2021

Covert Cognizance: A Novel Predictive Modeling Paradigm *A. Sundaram, H. Abdel-Khalik*

Reactor Physics Analysis Assessment of Feasibility of Using Advanced, Nonconventional Fuels in a Pressure Tube Heavy Water Reactor to Destroy Long-Lived Fission Products *B. P. Bromley, A. V. Colton*

Reactor Physics Assessment of Potential Feasibility of Using Advanced, Nonconventional Fuels in a Pressure Tube Heavy Water Reactor to Destroy Americium and Curium *B. P. Bromley, A. V. Colton*

Steady-State Subchannel Thermal-Hydraulic Assessment of Advanced Uranium-Based and Thorium-Based Fuel Bundle Concepts for Potential Use in Pressure Tube Heavy Water Reactors *A. Nava-Dominguez et al.*

Water Migration and Swelling in Engineered Barrier Materials for Radioactive Waste Disposal *J. McFarlane et al.*

Emissivity of Grade 91 Ferritic Steel: Additional Measurements on Role of Surface Conditions and Oxidation *F. N. Al Zubaidi et al.*

Development of a Gamma-Ray Radionuclide Library for the Identification of Gamma Spectra *P. L. Lagari et al.*

Development of an Integrated Computer Code System for Analyzing Irradiation Behaviors of a Fast Reactor Fuel *T. Uwaba et al.*

What can independent core analysis mean for utilities?

Erin Wehlage

Erin Wehlage is vice president of global marketing and sales at Studsvik Scandpower.

As a knowledge manager for the 2018 Utility Working Conference, I had many opportunities to interact with nuclear utility leaders. The discussions often centered around finding innovative ways to sustain the existing fleet of nuclear plants by improving plant economics.

As utilities try to find new ways to reduce operational costs and preserve the existing fleet, the ability to change fuel vendors based on price and performance has become increasingly important. One option is investing in licenses for independent software and methods that allow utilities to choose the advanced-technology fuel best suited for their cores and that permit the loading of mixed cores with fuel from different vendors. The increased fuel vendor competition could reduce fuel capital procurement costs by about 5 percent.

When a utility buys nuclear fuel or dry casks for spent fuel storage, regulator-approved simulation software is typically provided by the vendor for modeling and analysis, or a vendor may provide all design services for the site using simulation software tailored for that vendor's products. Procedures for reload design and dry cask storage loading campaigns are developed around the software, making it difficult and costly to transition to another fuel or cask vendor, since the simulation software and procedures would need to be changed and engineers would need to be retrained and qualified to use the new software.

Engineers at utilities that choose regulator-approved independent core analysis methods can perform their own reload and refueling shuffle design without paying a fuel vendor. Throughout my career, I've watched many utilities successfully make the transition to fuel vendor–independent core analysis methods. Independent software methods, like Studsvik Scandpower's software products, can model both boiling water reactors and pressurized water reactors, providing utilities a path to fleetwide standard methods. Larger nuclear fleets can reap more monetary benefits from independent software and methods due to economies of scale, but single-unit utilities and smaller fleets can also see the value of increasing in-house capabilities.

I'm looking forward to continuing the conversation on light water reactor sustainability at the 2021 UWC, and I'll see you on the golf course!

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