NuclearNews
August 2022

28th Annual Vendor/Contractor Profile Issue

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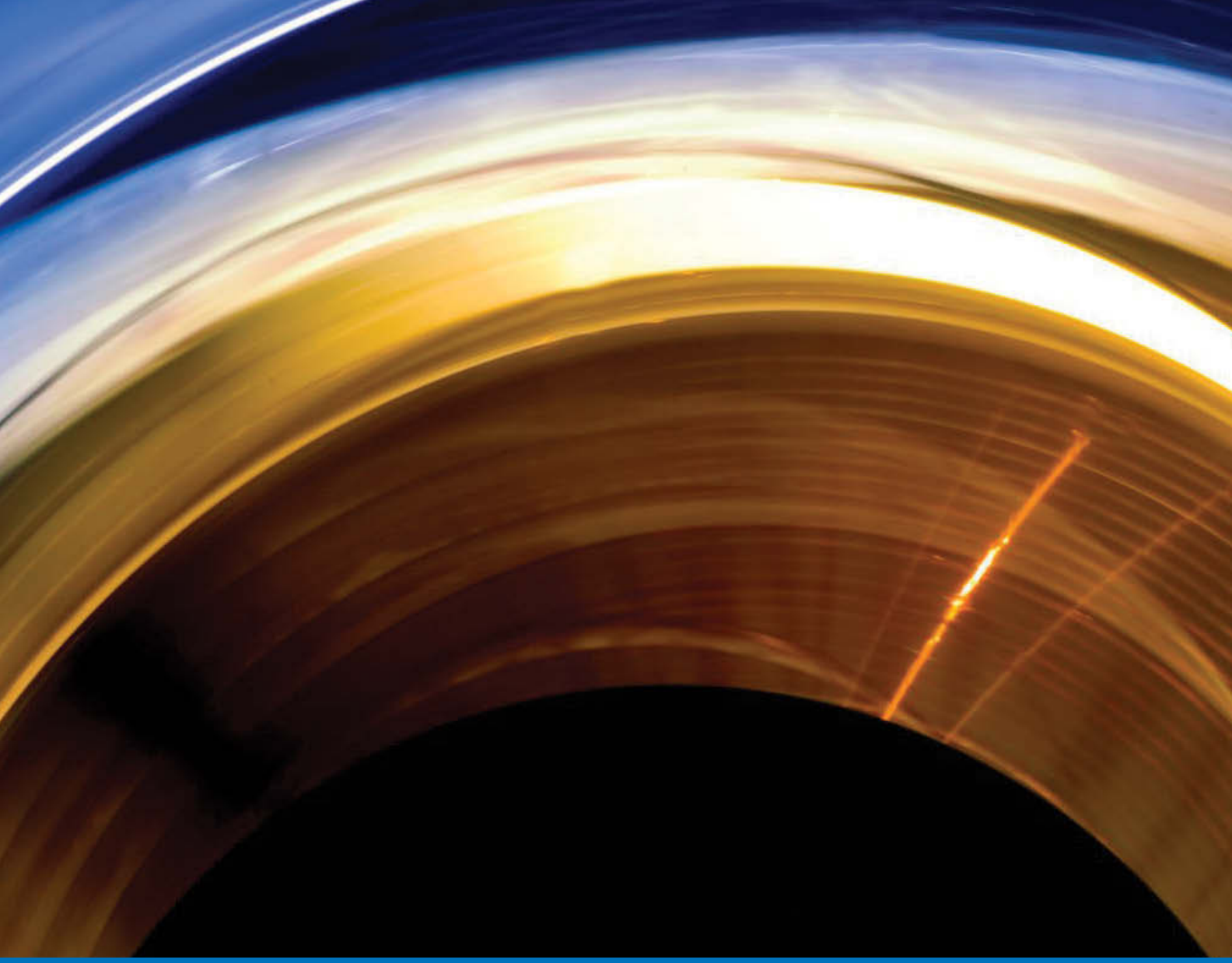

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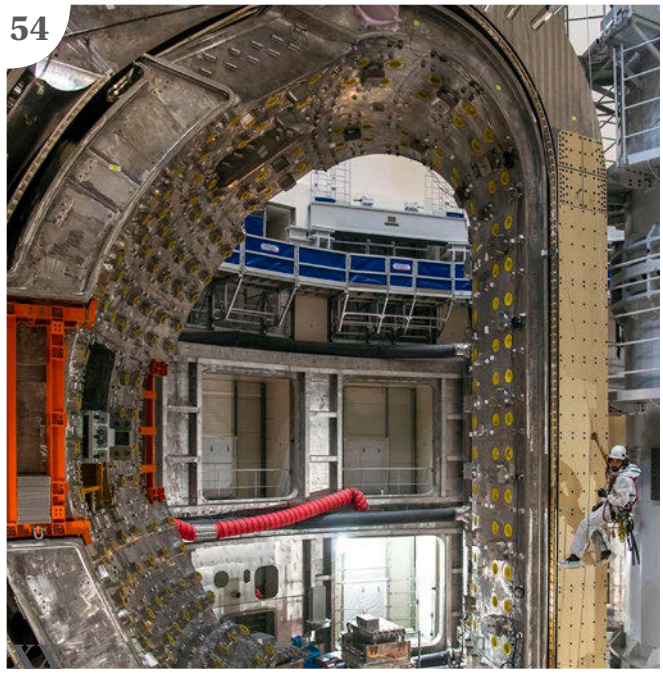

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American Nuclear Society

On the UWC, *Nuclear News*, and our supporters

Rick Michal, Editor-in-Chief
rmichal@ans.org

August is the month for the Utility Working Conference and Technology Expo, this year in Marco Island, Fla. The UWC is ANS's annual meeting that consistently generates practical recommendations designed to address the nuclear community's most pressing needs. In addition to the UWC's technical sessions and the opportunities to mingle and golf, its expo draws more than 70 vendors that offer their products and services.

August is also the month that *Nuclear News* publishes its annual Vendor/Contractor Profile issue, for which 2022 marks the 28th consecutive year of this theme issue's appearance.

What the UWC and the Vendor/Contractor Profile issue have in common is the support received from the businesses in the industry. Sponsors of UWC 2022 include Constellation, Duke Energy, Certrec, Framatome, GSE Solutions, Power Services Group, Southern Nuclear, Paragon Energy Solutions, Sargent & Lundy, United Engineers & Constructors, Westinghouse, Allied Power, BCP, System One, Toshiba America Energy Systems, HukariAscendent, Studsvik, Urenco USA, General Atomics Electromagnetic Systems, and G.D. Barri & Associates. And, for this issue of *NN*, the advertisers are many, as you will see when you leaf through these pages.

Readers may not realize just how much *NN* and ANS depend on the nuclear community's support for our publications and meetings. *NN*'s core readership—ANS members and the nuclear community—lends our magazine tremendous credibility, and so advertisers know that they are reaching decision makers in every sector of our industry and community.

To brag a bit, *NN* has relationships with more vendors and nuclear organizations worldwide and it publishes more advertisements than all other trade publications in this field combined. Whether a company's need is to find its next rising-star employee; promote a conference, workshop, or educational opportunity; or advertise their latest products and services, *NN* has proven itself to be the best partner to deliver corporate messaging to the nuclear world. The fact that *NN* has maintained its staying power and impact over the past six decades while many other publications have folded speaks to the reach and impact of ANS and its quality publications, which are produced throughout the year.

A final word from Jeff Mosses, ANS's director of sales, about the relationship between *NN* and its advertisers: "It's all about making sure companies are aware of all our offerings and customizing a plan that helps them achieve their objectives while maximizing their exposure within their budget limitations."

My final word to sponsors, supporters, and readers is "thank you." Thank you for being there, because without you, *NN* would not be here.

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Letters

Credit due

The July 2022 *Nuclear News* contained a good summary of the American Nuclear Society's comments on the Nuclear Regulatory Commission's proposed changes to its decommissioning regulations. The article (page 18) attributed the comments to me, which was technically correct—as I, as then ANS President, did sign the comment letter. However, Miles van Noordennen and a team from ANS's Decommissioning and Environmental Services Division compiled the excellent comment package. Technical divisions like DESD are the primary repository of the expertise that enables ANS to contribute substantively and effectively to the policy dialogue related to nuclear technology. ANS members, keep up the good work.

Steven Nesbit
ANS Immediate Past President

Let's revive the LMFBR

During my active career, I spent about 16 years working on the breeder reactor, including six years on the Clinch River Breeder Reactor Plant project, the government funding for which was terminated in the early 1980s. Since then, I have spent much time thinking about that experience and have concluded that if the reactor core of a liquid metal fast breeder reactor is designed to run for 10 years between refuelings (an objective that is achievable given the breeding that occurs in the core), all kinds of options become available for capital cost reduction.

I have captured my thinking on the subject by preparing a monograph, which is available on the website I created at lmfbr.com. The website is a place for comments and constructive discussion on the LMFBR. I welcome all ANS members with interest in the subject to visit the website and to make comments. Your participation could lead to new life for the LMFBR.

Clark Gibbs
Oxford, Miss.

Interim used fuel storage first?

For the past few years, the Department of Energy has been attempting to obtain advanced consent for interim (40 years) storage of spent nuclear fuel. At present, the DOE is soliciting advice on what constitutes consent, following strong resistance to an attempt to establish such facilities in Andrews County, Texas, and Lea County, N.M., next to existing low-level nuclear waste disposal sites. The Texas legislature has passed legislation forbidding storage of spent fuel, and senators from both states have jointly introduced legislation in Congress to forbid the proposed interim storage of spent fuel in their states.

The resistance is at the state level, whereas local residents favor the proposed storage. Note that the same disparity between state and local positions exists regarding Yucca Mountain and existed in regard to the proposal of the Goshute Indian Tribe to store spent fuel on their reservation in Utah.

After many public hearings, the Nuclear Regulatory Commission has granted a license to Interim Storage Partners for the Texas site, and a license is expected for Holtec for the New Mexico site. But there remains a question as to whether they will want to or be allowed to use those licenses.

We can assume that the DOE's priority for interim storage is based on the belief that it is easier to ask a region to accept temporary storage than to ask for permanent disposal.

Unfortunately, it doesn't work that way. In the absence of significant progress toward permanent disposal locations, fear arises that interim storage may become permanent. Several local opponents of the proposed sites have noted the absence of efforts regarding permanent disposal. Congressman Mike Simpson (R., Idaho) has flatly opined that there will be no interim storage of spent fuel until there is significant progress toward permanent disposal.

We see no choice but for the DOE to begin with seeking consent-based permanent disposal and later look for interim storage, while construction continues on an accepted permanent disposal site. To make permanent disposal of spent fuel more acceptable, the DOE should prioritize reprocessing the material to chemically separate the long-lived fission products and separate the actinides for consumption in a fast-spectrum reactor. Then we can talk about the need for burial safety for thousands rather than hundreds of thousands of years for more than 99 percent of the waste.

John Tanner
On behalf of the Idaho Section
of the American Nuclear Society

Continued

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Letters

Cost, safety, and nuclear waste disposal

Regarding the Opinion column by James Conca in the June 2022 issue of *Nuclear News* ("Do we need a final federal nuclear waste disposal facility to sustain our nuclear fleet?," page 76), while I agree with his premise that the nuclear fleet can be sustained without a waste disposal facility, he ignores two important points: cost and safety.

In his discussion of the Nuclear Waste Policy Act (NWPA), Conca does not mention the establishment of the Nuclear Waste Fund, which is supported by a small tax on the generation of nuclear power, nor the requirement that the Department of Energy take possession of the used fuel from the utilities beginning January 1, 1998. Thus, while the major cost to develop Yucca Mountain was paid for from this fund—and not the taxpayer, with a smaller portion from the Navy—the cost has now shifted to the nuclear utilities, hence the rate/taxpayers, to store the fuel at their sites. Most public utility commissions have successfully sued the DOE to reimburse the utilities for the cost—in the hundreds of millions of dollars—of above-ground steel and concrete casks for the dry storage of used fuel, since the on-site storage pools were not of sufficient size to meet this new need. These reimbursement funds came from the Treasury Department, and therefore, the taxpayers.

It has been well established that the safest way to disposition used fuel, with or without reprocessing, is deep underground storage. The first report on this subject was developed by the National Academy of Sciences (NAS) in, I believe, 1957, when the first small nuclear plants began operating. This approach has since been supported by many national and international studies. Most of these studies focused on the degradation of the fuel and the potential release of radioactivity and resultant exposure to the public, and not its physical safety. Physical protection has become more important with the creation of concrete pads holding dozens of casks at some 60 sites across the United States. Some sites where the reactors have been dismantled still have pads containing used fuel requiring security. Conca recognized the need for above-ground monitored retrievable storage facilities, but not the fact that such sites would be more secure than the utility sites. While there has been progress in the licensing of such sites, no governor has granted permission to proceed with construction. Progress on an alternate deep underground storage facility has been even slower.

I would also like to comment on meeting the Nuclear Regulatory Commission's regulations regarding the licensing of the repository. In about the early 1990s, the performance assessment of the repository shifted from focusing on either the rock system, the natural barriers, or the remaining engineered barriers to a total system approach that took advantage of the features of both the natural and engineered barriers. This is consistent with the same approach adopted by the NRC and that of the international community. For Yucca Mountain, utilizing both systems allowed the DOE to easily meet the NRC requirements for both the short term and the very long term.

David Stahl
Las Vegas, Nev.

James Conca responds: I apologize for not discussing the NWF in my column in the June issue. It was not critical to the discussion of whether the operating nuclear fleet could continue without a final waste repository, and I have discussed it in detail elsewhere, including in my column in the May issue of *NN* ("Comparing costs for deep geologic nuclear waste disposal," page 82), in which I discussed how the NWF does not have sufficient funds, nor will it ever, to make Yucca Mountain the final repository. Suing the DOE for dry cask storage operations doesn't really affect this discussion, either.

I did not specifically mention the 1998 date for the DOE to take possession of used fuel but did mention that the NWPA calls for the DOE to find a disposal site, build, and operate it—which they have not done, and which has not stopped the fleet from operating.

Siting and licensing a centralized interim storage facility, again, does not relate to this discussion and has the same hurdles as siting a repository, that is, strong feelings of "not in my backyard."

I did not mean for this discussion to be a complete history of nuclear waste disposition, just whether it would close down our fleet prematurely.

The 1957 report published by the NAS [*The Disposal of Radioactive Waste on Land*] was correct when it concluded massive salt was the best host rock. In the 1970s, a push to add retrievability to the disposal system resulted in jettisoning salt in favor of hard rock

and thus led to changes in performance assessment from one that depended primarily on rock to one that depended on engineered barriers—altogether a foolish strategy that began our problems with nuclear waste. Requiring a total systems approach is really a euphemism for "we picked the wrong rock."

Since the Topopah Spring tuff was chosen primarily on the basis of politics, it is not surprising that it would be such a poor rock with regard to performance—something we didn't fully realize until we had researched it for almost 20 years. Being a highly fractured, dual-porosity, variably saturated system that constantly drips oxidizing water, the necessity for numerous engineered barriers was obvious. This was the beginning of the rise in the final cost of the repository to the point where the NWF would not cover it and Congress will have to appropriate additional funds, more than would ever be in the NWF. This is highly unlikely.

As one of the original authors of the DOE Yucca Mountain license application to the NRC who worked on Yucca Mountain technically for 15 years prior to the application (especially on the engineered barrier systems), I can say that dependence on human-made engineered barriers is unwise and unnecessary given America's preponderance of massive Permian salt deposits, especially in the Delaware subbasin where the Waste Isolation Pilot Plant resides. The idea of retrieving spent nuclear fuel after it's buried is absurd and needs to be abandoned or we will never dispose of this material. And that might jeopardize seriously expanding our nuclear fleet in the future. But these issues do not impact whether we need a final repository to sustain our existing nuclear fleet. We don't . . . at least not for a long while.

Readers Write

Readers Write 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.

Emphasis on the state-of-practice

This note is in response to the submittal "An approach to a nuclear recovery," which appeared in the Readers Write section (page 6) of the May issue of *Nuclear News*.

I share the author's general opinions expressed in that piece: that nuclear power plants can be safely designed and operated, and that there is the need for further improvements in the current nuclear processes to ensure further viability of the industry while ensuring an outstanding track record. I also agree that, for structures, systems, and components (SSCs) of low safety significance, the potential for a procurement path that includes normal commercial items should be considered.

However, I feel strongly compelled to address the statement that it is "a little-known fact that much, if not all, of the failure data used in risk assessment are based on the reliability of commercial items, not on those with a nuclear pedigree." To the extent that this is applied to probabilistic risk assessment (PRA) analysis for nuclear power plants, it is not reflective of the state-of-practice.

Current PRA models use failure rates for SSCs almost completely derived from nuclear power plant experience. Operating experience data are carefully collected by the Institute of Nuclear Power Operations, analyzed by organizations such as Idaho National Laboratory for the Nuclear Regulatory Commission, and provide a structured approach to collect, classify, and ensure the appropriateness of applying such events in the proper context and boundary conditions. The use of this nuclear industry experience is integral to PRA models used across all U.S. nuclear power plants. The failure rate data for safety-related and non-safety-related SSCs are routinely derived from operating experience with similar SSCs. The information is contained in publicly available reports (NUREGs) and NRC-maintained public websites and databases, such as https://nrcoe.inl.gov/, that can be made accessible to practitioners. While commercial data could be used to augment available information where there are insufficient or unavailable data, this should be exception—not the rule.

The reason it is important to correct the above statements is that PRA modeling is indeed "one of the most useful tools" to ensure the longevity and safety of the nuclear reactors in operation around the world. And, as such, it is important to properly recognize the quality of the information included in the models, its pedigree, the effort performed by many organizations (including nuclear utilities that report operating experience), and the extent to which they reflect the outstanding performance of the nuclear industry. A significant portion of this effort is thanks to the efforts of the ASME/ANS Joint Committee on Nuclear Risk Management, which oversees the development, maintenance, and application of PRA standards that include requirements for the usage of failure rate and other inputs into the PRA models to ensure the success of efforts such as 10 CFR 50.69, risk monitoring of maintenance activities, risk-informed fire protection, and so many other already implemented efforts.

Fernando Ferrante
Germantown, Md.


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Waste Management


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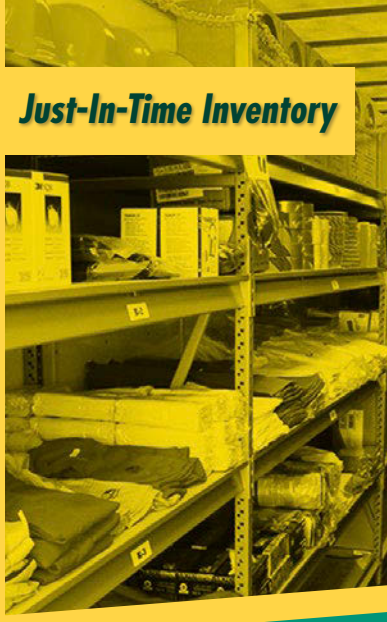
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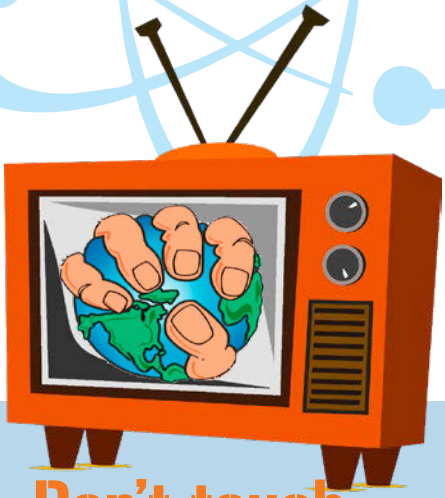
ENERGY CRISIS: Then and Now

Energy Crisis—these two words appeared repeatedly in *Nuclear News* in the 1970s, in letters to the editor, features, news reports, and job ads. Now, a new global energy crisis fueled by Russia's invasion of Ukraine is drawing comparisons.



Don't touch that dial

Cue ominous chords and fade in from black to a spinning globe . . . you're watching ANS's 1976 public service TV spot that showed the earth being squeezed dry of its last drops of oil by a giant hand and urged more "safe, reliable, and economical" nuclear power plants. The narrator's last words, intoned over a fading sunset, still ring true: "Our world is hungry for energy, and we must move ahead to preserve our future. If we don't, we could find ourselves in the dark ages of the seventies."

ANS mailed 30- and 60-second "Energy Awareness" spots on 16-mm film directly to about 300 television stations around the country and reported that they were viewed by over 80 million in just three months; in 1977, 600 stations received a new set of clips.

Why TV? A *Nuclear News* ad encouraging members to buy the spots and forward them to their local station said, "Recent surveys have shown that 50 percent of the public is yet to be convinced that we do indeed have an energy crisis. Secondly, the medium of television has the most credibility with the public . . . and finally, TV viewers are split 50-50 regarding the subject of nuclear power."

Another century, another crisis

"The energy crisis has not yet overwhelmed us, but it will if we do not act quickly." So said President Jimmy Carter on April 18, 1977, in a televised address. "It's a problem that we will not be able to solve in the next few years, and it's likely to get progressively worse through the rest of this century."

Carter went on to announce that the Energy Research and Development Administration—formed just three years earlier from the breakup of the Atomic Energy Commission—would be combined with most other federal energy activities to form a new cabinet-level agency: the Department of Energy. Forty-five years later, the DOE has another chance to respond to an energy crisis by supporting reliable and secure energy sources.

Survey says

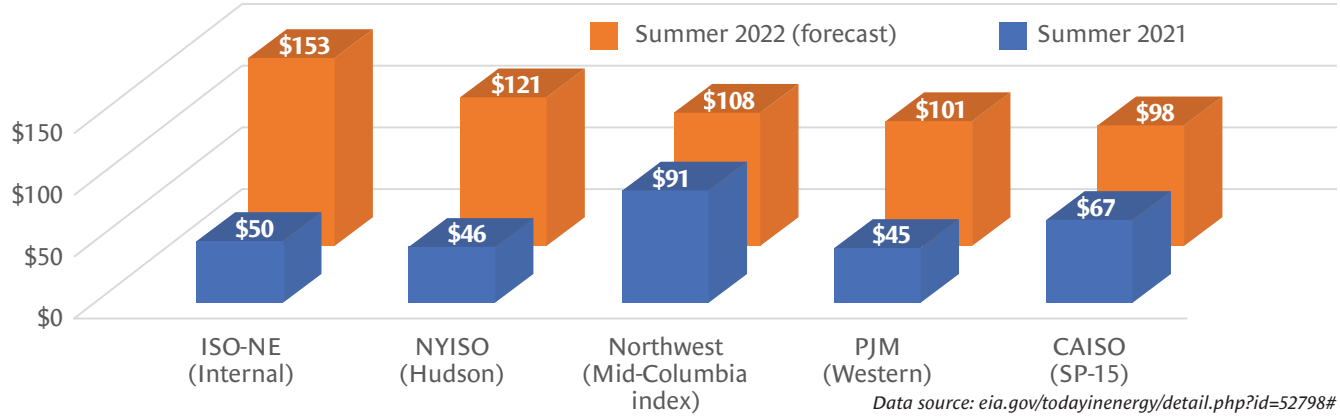
A commercial survey conducted in July 1976 and reported in the January 1977 issue of *Nuclear News* found that 80 percent of the general public from 1,497 households surveyed believed the energy shortage at the time was "serious," while half of those respondents said it was "very serious." Of the same respondents, 61 percent favored nuclear power expansion (the prospect of cheaper electric power was identified by 77 percent as a "major advantage" of nuclear power), while 22 percent were opposed and 17 percent not sure. Further, 64 percent thought the energy shortage would still be "serious" in 10 years. In the end, overproduction and conservation triggered an oil glut and a price drop in the early 1980s.

Present crisis

Wholesale electricity prices—tied to rising natural gas prices—have consumers feeling the pinch right now. According to the U.S. Energy Information Administration's latest Short-Term Energy Outlook, summer prices in wholesale electricity markets are expected to more than double in some markets over 2021 prices as the average price of natural gas delivery to electricity generators climbed to an estimated average of $8.81/MMBtu, up from $3.93/MMBtu last summer. Four of the five markets with the highest forecasted prices could peak above $100/MWh between June and August 2022.

There's an upside for nuclear power utilities with predictable fuel prices, of course, and that boost to the bottom line may just spur investment in life extensions and new reactors.

Summer average wholesale electricity prices at selected price hubs (June–Aug. 2021–2022)

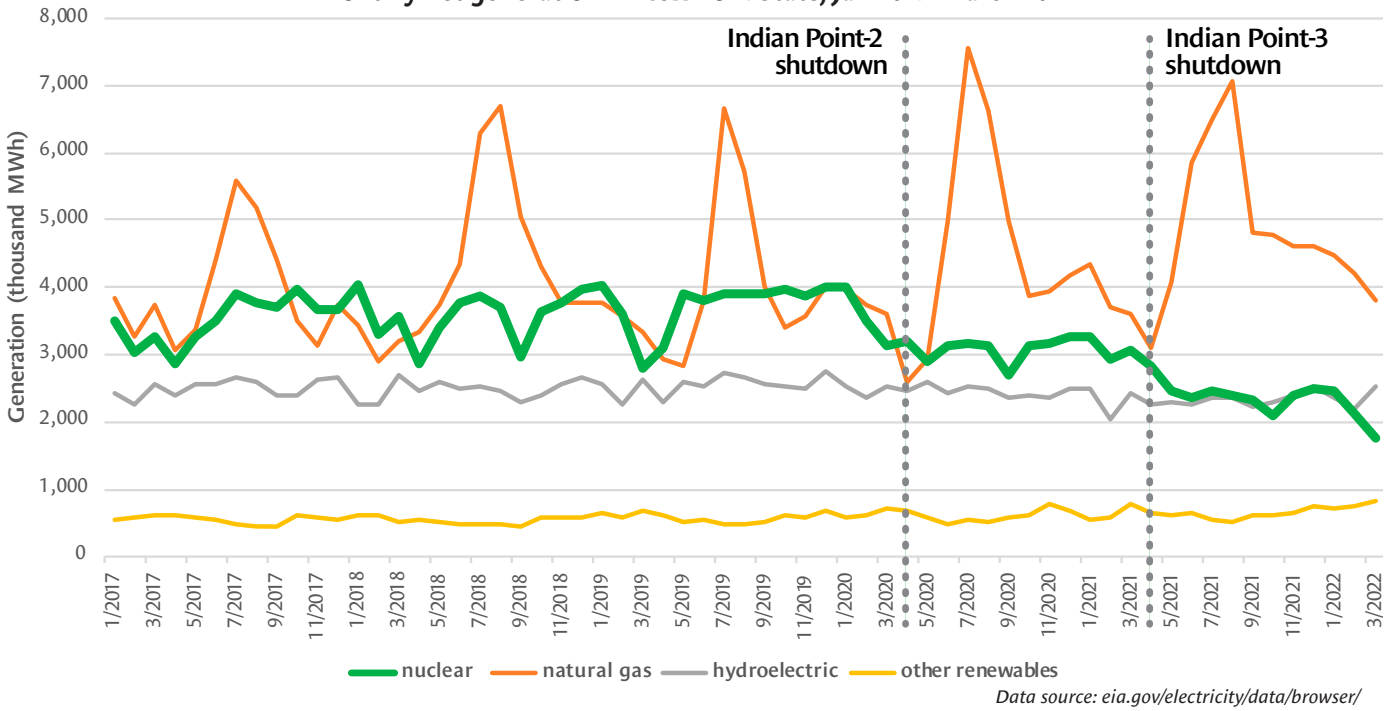


Data source: eia.gov/todayinenergy/detail.php?id=52798#

Focus on New York

The closure of Indian Point's two reactors in April 2020 and April 2021 made electricity scarcer and reliance on natural gas higher in the state of New York, increasing the pain of natural gas–fueled NYISO price spikes.

Monthly net generation in New York State, Jan 2017–March 2022



Data source: eia.gov/electricity/data/browser/

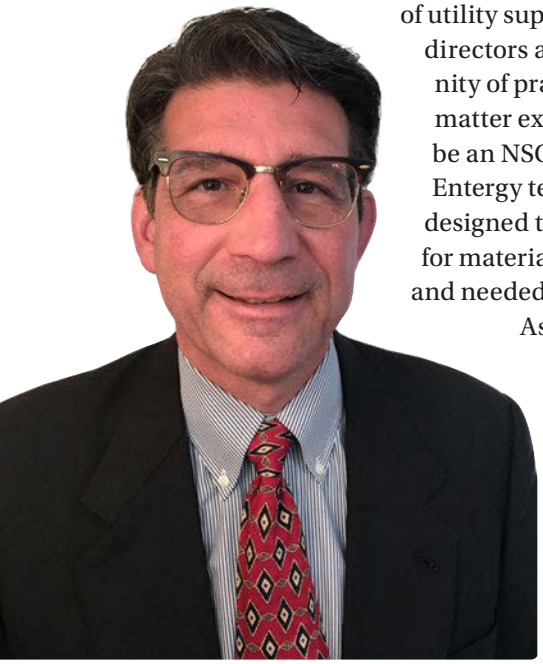
Collaboration and teamwork are crucial to solving nuclear supply chain challenges

By George Shampy

Across the country, supply chain issues continue making the news: price escalation, inflation, logistical delays, scarcity of products and services, obsolescence, risk associated with just-in-time inventory, equipment and service quality, and—especially in nuclear—the financial pressures to reduce costs while maintaining our focus on safe, secure, and reliable plant operations.

Unfortunately, these are not new challenges for nuclear supply chain professionals.

In fact, in 2001, the Nuclear Energy Institute formed the Nuclear Supply Chain Strategic Leaders Group (NSCSL) in conjunction with the Institute of Nuclear Power Operations (INPO) and Electric Power Research Institute (EPRI). The NSCSL is composed of utility supply chain managers and directors and serves as the "community of practice" for these subject matter experts. I am privileged to be an NSCSL participant and an Entergy team member. The NSCSL was designed to be the industry go-to group for materials and service collaborations and needed supply chain solutions.



George Shampy (gshampy@entergy.com) is senior manager of supply chain for Entergy Corporation.

As we look to the future, I believe collaboration among the nuclear operating utilities must be improved. We cannot afford to lose the common bond that is unique to our industry: "What happens at one station or utility impacts us all." The 1979 Three Mile Island accident taught us that lesson, and the creation of INPO is another result—a much-needed organization designed to drive excellence in nuclear operation by collaboration among utilities, continuous improvement, and self-regulation.

The stated mission of the NSCSL is to define, prioritize, and resolve nuclear supply chain industry issues and to encourage the identification and implementation of best supply chain practices to promote the advancement of nuclear power operations. NSCSL leaders have been instrumental in developing INPO supply chain documents; taking an active role in the Fukushima industry response; providing input into INPO equipment reliability documents and numerous EPRI documents related to vendor performance management; and developing parts for quality initiatives, industry supply chain training, and improved inventory sharing processes. Throughout the years, the team has also worked with suppliers to encourage them to keep up nuclear product lines and remain in our industry.

We are at a pivotal point that requires collaboration among the entire industry. We need effort within the utilities, among the utilities, and with our suppliers to weigh the scales in our favor for long-term success of the operating units. Even with 93 percent capacity factors, plants continue to be closed, which reduces the customer base for our suppliers. The interdependence of everyone in the industry is clear, and that makes cooperation vital.

Supply chain must be considered as a strategic business partner and be integrated into the business model and decision-making within utilities. Yes, to get and keep a seat at the table, supply chain must consistently deliver solutions. Supply chain is a unique

function that interfaces with every team—e.g., finance, quality assurance, engineering, and maintenance and operations—to understand their requirements and needs. Early engagement with supply chain by the business has a proven track record of delivering positive results. This is called cross-functional engagement and is a key element of the recommendations in the recent INPO report IER 21-4, *Improving Plant Reliability*, to drive continuous improvement. Collaborating early and often with supply chain team members can prevent and mitigate issues. The goal is to reach agreements that benefit both supply chain and their customers.

Collaborating with suppliers that are committed to the industry is key to our success. As the industry's footprint gets smaller, suppliers and their customers—we, the utilities—must work together. Sharing insights on equipment challenges, operating enhancements, and demand plans for future utilization are all a part of collaboration. Suppliers have a vested interest in improving and maintaining their solutions to enhance the customer experience and plant reliability. They rely upon the information to innovate and to plan their business operations. INPO IER 21-4 also promotes engagement with suppliers and original equipment manufacturers. A stellar example of this is Entergy leadership that champions cross-functional engagement, industry benchmarking, and partnering with our suppliers and OEMs, regularly in calls and routinely making updates to reinforce these behaviors for success.

As processes have been reengineered, we have embraced new technologies to reduce operating costs, and we have implemented continuous improvements in pursuit of delivering the nuclear promise. Such improvements include standardized engineering, centralized procurement, risk-informed regulation and code cases, with a focus on the utility bottom line. By focusing our resources on operating safely and economically, there could be an unintended consequence to our supplier's bottom line. These improvements will impact remaining suppliers, many of which have been committed to the industry for more than 50 years. Thus, collaboration with our suppliers will help improve product quality, standardize equipment, reduce cost, increase innovation, and maintain a healthy supply base.

It is imperative that we work together—as one, unified supply chain team. Strengthening the commercial viability of the existing nuclear fleet, and assisting in the expansion of nuclear with small modular reactors, will help pave the way for a bright and successful future for clean, carbon-free nuclear energy.

The Level 1 probabilistic risk assessment standard for nuclear power plant applications

By Patricia Schroeder

The American Society of Mechanical Engineers/American Nuclear Society Joint Committee on Nuclear Risk Management (JCNRM) has issued a new edition of its flagship standard, ANSI/ASME/ANS RA-S-1.1-2022, *Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications*. This standard was approved by the JCNRM, the ANS Standards Board, and the ASME Board on Nuclear Codes and Standards before being approved on May 11 by the American National Standards Institute (ANSI), earning the title of an American National Standard. With most of the text stable for the past year, the production process was started early, allowing the 400-page standard to be published on May 31, 2022.

ANSI/ASME/ANS RA-S-1.1-2022 states requirements for a Level 1 probabilistic risk assessment of internal and external hazards while at power for the evaluation of core damage frequency. In addition, this standard states requirements for a limited Level 2 PRA sufficient to evaluate large early release frequency. This standard provides specific requirements for hazard groups on internal events, internal floods, internal fires, seismic events, high winds, external floods, and other hazards. The only hazards explicitly excluded from the scope are accidents resulting from purposeful human-induced security threats (e.g., sabotage, terrorism). These requirements are written for operating light water reactor power plants (i.e., plants with designs and features similar to current operating plants). Dennis Henneke with GE Hitachi Nuclear Energy and JCNRM cochair for ANS stated, "This is the PRA standard used by all existing operating nuclear plants in the U.S. and many around the world to support risk-informed applications." He added that the standard may also be used for LWR plants under design or construction or for advanced LWRs; however, revised or additional requirements may be needed.

The use of this standard provides a technical basis to support operational risk management for nuclear power plants. Risk-informed analyses that use the PRA standard as their basis have made substantial improvements in nuclear power plant safety and optimization as seen by the industry's continual safety and operational improvements. These areas include such risk-informed programs as the Nuclear Regulatory Commission's reactor oversight program, maintenance rule, risk-informed completion times, surveillance frequency control programs, and 10 CFR 50.69, among others.

The draft for the revision of this Level 1 PRA standard was finalized and issued to the JCNRM for approval in December 2019. Six additional ballots to approve changes, some with recirculation ballots, were issued over the next two years. In all, well over 2,000 comments were received, and each one was addressed by the writing teams for the relevant parts (e.g., Parts 1–9). The final ballot, while not unanimous, closed in January 2022 with substantial consensus of the diverse 34-member committee. With consensus reached, the draft was made available for public review through April 4, 2022, by ANSI, resulting in no additional comments. The ANS Standards Board certified the ballot process on May 11, 2022, paving the way for ANSI approval.

The 2022 edition of this standard is a substantial improvement over ASME/ANS RA-Sb-2013, *Addenda to ASME/ANS RA-S-2008 Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications*, and the Part 5 case issued in 2017.* Work on the Level 1 standard revision was initiated in 2013 following the release of ASME/ANS RA-Sb-2013. Andrea Maioli with Westinghouse Electric Company and JCNRM vice chair for ANS explained, "ANSI/ASME/ANS RA-S-1.1-2022 went through a significant effort of harmonization of the requirements across different hazards, for example, harmonizing screening criteria or the treatment of operator actions, so that the risk profile of a nuclear power plant is more consistent and considers the inherent uncertainties associated with different hazards." He added, "The standard has expanded very significantly the details associated with PRA model for external hazards, specifically for high winds and external flooding PRAs, updating the standard to more than 20 years of practice in those fields that were previously not captured—if not in a relatively high-level fashion—and [the standard] includes the lessons learned from all the seismic PRAs performed in the post-Fukushima era."

In addition to a major reformatting and inclusion of lessons learned, significant changes include the following:

- Implementation of changes to strengthen consistency among technical elements that are cross-cutting through different hazards.
- Addition of back references from part to part to facilitate the peer review process.
- Removal of Capability Category III across the board on the basis that Capability Category II already envisions refined analysis and realism implemented for the risk-significant elements.
- Addition of a new section to assess the technical adequacy of newly developed methods.
- Removal of "PRA maintenance" and "PRA upgrades" examples now addressed by the Pressurized Water Reactor Owners Group.
- Expansion of technical requirements for maintaining configuration control of the PRAs and for the review of new methods applied to nuclear risk analysis.
- Consolidation of all peer review requirements into one section in Part 1 to remove inconsistencies and duplicated information from different parts.
- Incorporation of the clarification regarding the scope of walkdowns documented in JCNRM Inquiry 20-2435 in the nonmandatory appendices for all walkdown supporting requirements.**
- Revision of notes and commentaries to ensure content is up to date and, for the most part, removal of such material from the body of the standard to associated nonmandatory appendices.
- Addition of a new appendix that provides the meanings of action verbs used in requirements.
- Addition of new and revised definitions for clarity.
- Deletion of Part 10 on seismic margin assessment.

The NRC's Regulatory Guide 1.200 (Rev. 3), "Acceptability of Probabilistic Risk Assessment Results for Risk-Informed Activities," currently endorses ASME/ANS RA-Sb-2013. It is expected that the NRC will endorse the 2022 edition of this standard in the next revision of RG 1.200. Henneke said, "ANSI/ASME/ANS RA-S-1.1-2022 will continue to be the yardstick for evaluation of PRA technical adequacy through industry-led peer reviews that the NRC relies upon to assist in the review and assessment of each individual PRA plant model."

The ASME Board on Nuclear Codes and Standards and the ANS Standards Board formed the JCNRM in 2011 to develop and maintain PRA standards. The JCNRM operates under procedures accredited by ANSI as

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*ASME/ANS RA-S Case 1, available at https://cstools.asme.org/csconnect/FileUpload.cfm?View=yes&ID=52986 (current as of Jul. 1, 2022).

**Inquiry response available at https://cstools.asme.org/csconnect/CommitteePages.cfm?Committee=100186782&Action=40886 (current as of Jul. 1, 2022).

meeting the criteria of consensus procedures for American National Standards. Acknowledgment for the development of ANSI/ASME/ANS RA-S-1.1-2022 is given to the collection of JCNRM committees made up of more than 200 professionals in the industry from four continents and spanning the extensive interdisciplinary breadth needed for the development of multihazard, full-scope, comprehensive assessments. Participants included top experts in PRA and associated hazards with representation from the NRC, the Electric Power Research Institute, U.S. nuclear utilities, nuclear steam supply system vendors, PRA consultants, university and national laboratory experts, and individual PRA experts. A full list of committee members dedicated to this effort can be found in the standard's preview available at techstreet.com/ans/products/preview/2255559.

JCNRM cochair for ASME C. Rick Grantom, principal of C. R. Grantom P. E. Associates, hints at what is to come for the joint committee: "The JCNRM is now turning its focus toward the next generation of nuclear power plants while continuing to support current operational plants by developing standards and guidance products to support other significant risk-informed applications to help ensure that nuclear power plants continue their exemplary service."

For more information on the JCNRM and other ANS standards efforts in the PRA and risk-informed, performance-based areas, please visit ans.org/news/article-3262/.

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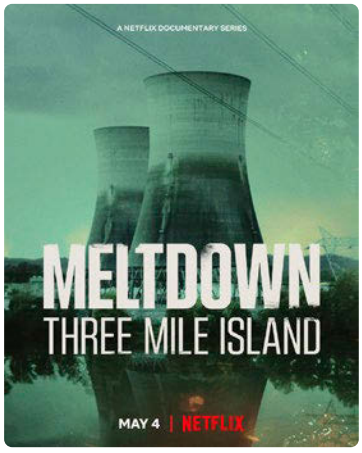
Meltdown: Three Mile Island—Drama disguised as a documentary

By John Fabian

The Three Mile Island accident in 1979 was the most-studied nuclear reactor event in the U.S. There is a plethora of research about the accident available to the general public, including the president-appointed Kemeny Commission report and the Nuclear Regulatory Commission's Rogovin inquiry report (split into volume one, and volume two, parts one, two, and three), which are the two detailed government-sponsored investigations into the accident. There are also thousands of documents in the NRC's ADAMS database available to the public, an excellent overview by NRC historian Samuel Walker titled *Three Mile Island: A Nuclear Crisis in Historical Perspective*, as well as the *Nuclear News* special report from April 1979 and articles written by ANS members like William Burchill about the accident and the many changes it forced on the industry. If the producers of *Meltdown: Three Mile Island*—available on Netflix—had read any of those documents instead of relying mostly on input from antinuclear activists, their "documentary" might have been presented with at least some sense of balance and credibility.



Instead, *Meltdown* focuses on drama instead of science. This four-part miniseries does not attempt to provide a balanced set of facts from the technical community and relies heavily on nonexpert opinions and anecdotal statements to tell a story that easily falls apart under even the faintest scrutiny.

NN reached out to multiple ANS members who were involved with either the accident response or the cleanup to help provide a critical look at some of the more egregious statements made in the documentary.

Initial reactions

ANS immediate past president Steve Nesbit sums up the feelings of the nuclear community well in response to this deceptive documentary: "Boiled down to its essence, this docudrama consists of numerous unsubstantiated statements and allegations by Richard Parks and others presented as experts on nuclear power. But the statements and allegations were never subjected to any scrutiny—they are simply presented with no rebuttal. The facts contradict the implications of the Netflix special. The truth is that since the accident at Three Mile Island, nuclear power plants have operated safely, efficiently, and reliably as the backbone of the U.S. electricity grid."

The only real nuclear expert given the chance to refute some of the documentary's claims is Lake Barrett, a former NRC and Department of Energy official. Barrett informed *NN* that he was in fact interviewed for more than three hours by the producers of the documentary, but barely five minutes of that interview made it into the show. How can a documentary claim any credibility when the expert brought in to provide balance is excoriated and vilified?

(ANS Executive Director/CEO Craig Piercy later interviewed Barrett to provide the balance that was severely lacking in the Netflix series. A recording is available at ans.org/webinars/archive.)

"Following HBO's award-winning miniseries *Chernobyl*, Netflix has decided to take a shot at Three Mile Island. But they whiffed," said Jack DeVine, an ANS member who managed recovery engineering and technical planning at TMI after the accident. "This is the kind of nuclear phobia–inducing, irresponsible journalism that hastened our nation's withdrawal from nuclear energy

and thus has contributed to our tenuous energy and environmental position today," he added. "Their documentary misses the important lessons of TMI completely—and it comes at a time that we must give serious, well-informed consideration to building new nuclear plants." Indeed, *Meltdown* fairly melts down trying to make a connection between TMI and Chernobyl, even though the latter was a completely different type of accident that was not even possible at TMI.

Uncertainty and fear

The show does a good job describing the poor, unorganized communication from the industry and government to the public and the resulting panic. The psychological pressures and emotional reactions from the general public during the accident should not be minimized by anyone when discussing the accident.

In *Three Mile Island and Beyond: Memories of a Life in Nuclear Safety*, Harold Denton, the NRC's director of nuclear reactor regulation who was appointed by President Carter as the government's lead on-site in response to the accident, describes the confusion, fear, and panic among the public at the time of the accident and how the disjointed response from the government and industry pushed the local population through a period of unbelievable stress and tension. Denton quotes from residents' letters he received at the beginning of each chapter; one letter read, "I did not evacuate the area during the recent crisis, but I did help friends and relatives do so. Needless to say, the toll in human suffering was great, mainly in terms of the psychological stress generated by our loss of control over our own lives."

Denton, whose role was not thoroughly discussed in the documentary, had been brought in to streamline communications about the crippled power plant and be the sole source of information to the media. He wrote, "A substantial portion [of letters he received from the public] also expressed people's fears for their safety. Feeling safe is a very individual and subjective thing, affected by both our thoughts and our emotions—with emotions being the stronger of the two. What feels safe for one person doesn't necessarily feel secure to another, and I think this is part of what lies behind so many disputes around nuclear power." *Meltdown* clearly focuses on the emotional response to fear and uncertainty when describing the events of the accident—which is merited, but the series does not give a voice to the thousands of men and women who worked around the clock to respond as events unfolded at TMI.

Radiation release from the accident

While the show did portray the poor communication, lack of understanding by the plant operators, and tension within the communities around the power plant reasonably well, it failed when discussing the actual technical evidence about the accident. For example, there are multiple statements throughout the show that no one really knew the amount of radiation released from the power plant, which is completely false. Then, near the end of the first episode, there is a clip that states one radiation reading was measuring radiation levels at 1,200 mrem per hour, but this reading was actually taken directly over the exhaust vent in the auxiliary building and not a reading at the site boundary. The show does not make that distinction, intentionally misleading viewers. This attempt to sow doubt and spread fear in the minds of the viewers went uncontested, even though there is plenty of evidence to the contrary.

In the NRC's Rogovin report, a map (reproduced here on p. 22) shows all of the radiation monitors set up by the utility, the NRC, and the Environmental Protection Agency.

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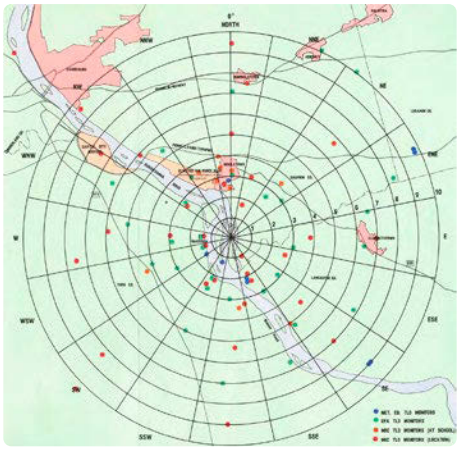
The radiation monitors outside of the plant did in fact measure elevated radiation levels, but the highest reading was 7 mrem per hour, whereas the majority of monitors were in the range of 1 mrem per hour (Walker, *Three Mile Island*, p. 84). According to the Rogovin report, the levels of radiation monitored showed an average off-site dose of 1.4 mrem over the course of the accident (roughly 1 percent of the annual dose a person receives from background radiation), and the highest off-site dose was less than 100 mrem—levels nowhere near enough to cause any important negative health effects (Rogovin report, p. 408).



This map of the area around the TMI power plant shows the various locations of thermoluminescent dosimeters that were placed by the utility, the NRC, and the EPA.

As reported by *NN* in a special release in April 1979, the NRC announced cumulative data from environmental monitoring that included air, water, soil, and milk samples from the area around the TMI power plant on April 3, 1979—a week after the accident. The radioactivity in the area thankfully was minimal:

- The thyroid dose to anyone drinking the water was estimated to be less than 0.2 mrem per day.
- The maximum activity detected in the air was about one-fourth of the permissible concentration according to 10 CFR 20 (at the time of the accident).
- The thyroid dose for anyone drinking milk was estimated to be less than 0.5 mrem per day.
- No radioiodine was detected in any of 147 soil samples, nor in 171 vegetation samples taken off-site within 3 kilometers of the site.

To put these numbers into perspective, the Rogovin report states, "The annual background dose in Denver, where there is higher exposure because of the higher elevation (more cosmic rays), is 193 millirems, and the average dose in Harrisburg, Pennsylvania, near TMI, is 116 millirems. NRC regulations permit plant workers to receive doses up to 3 rems every 3 months."

Those very low levels of radioactivity confirm the findings of the Kemeny Commission: "In spite of serious damage to the plant, most of the radiation was contained and the actual release will have a negligible effect on the physical health of individuals." As noted by Tom Wellock in his book *Safe Enough? A History of Nuclear Power and Accident Risk*, some claimed a silver lining when reviewing the TMI accident. "There were no measurable health consequences despite a significant core meltdown . . . defense in depth had worked in protecting the public, but not in protecting a billion-dollar investment" (p. 77).

Health effects from radiation release

After erroneously claiming that the real radiation levels were unknown to the public, *Meltdown* goes on to try and link radiation levels from the plant to claims that the incidence of cancer and other sickness increased as a result of the accident. Once again, facts or studies have been ignored or dismissed, and the show relies only on anecdotal evidence from a very few local residents. To bolster their claims, they use a lot of dramatic images of dead fish and, in one case, of a young lady with what appears to be burns on her skin.

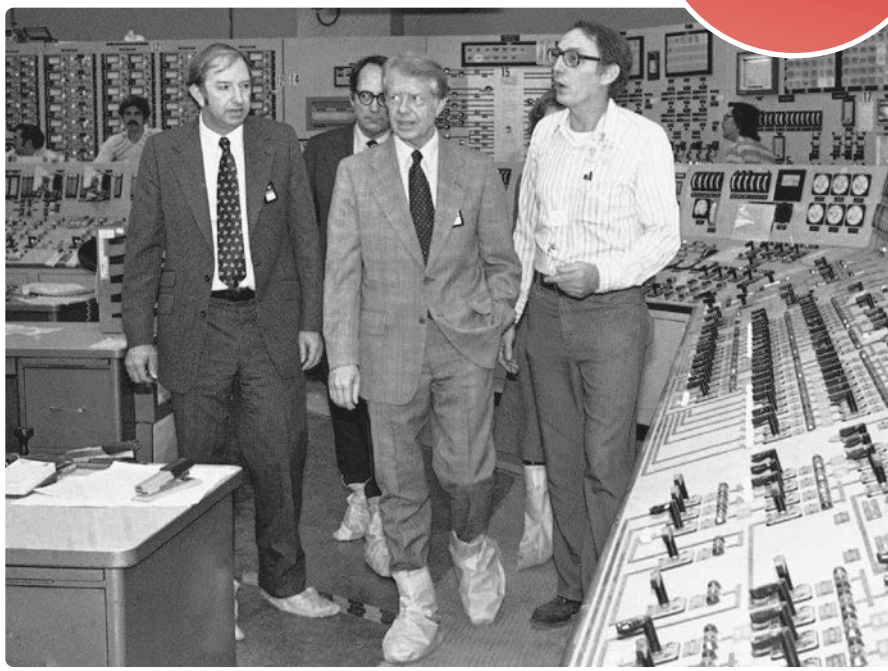
Just using projections based on the radiation measurements discussed above, both the Kemeny Commission report and the Rogovin report expected little to no negative health effects to the public. Anecdotal evidence of people suffering from cancer is not proof of sickness from radiation. According to the Kemeny Commission: "We know from statistics on cancer deaths that among the more than 2 million people living within 50 miles of TMI, eventually some 325,000 people will die of cancer for reasons having nothing to do with the nuclear power plant. Again, this number is only an estimate, and the actual figure could be as much as 1,000 higher or 1,000 lower. Therefore, there is no conceivable statistical method by which fewer than 10 additional deaths would ever be detected. Therefore, the accident may result in no additional cancer deaths or, if there were any, they would be so few that they could not be detected" (pp. 12–13).

There were in fact health studies done following the accident. In *Three Mile Island*, Walker discusses these series of health studies conducted in the area around TMI (p. 234). The first study, which was conducted by the Pennsylvania Department of Health and the Center for Disease Control in April 1980, concluded that "neither fetal nor infant mortality had risen in the six months following the accident within a ten-mile radius of TMI." Four years later, another study from the state health department "undertook a preliminary evaluation of cancer deaths within a twenty-mile radius between 1974 and 1983. The survey showed that cancer deaths were no higher than normal after the accident" (p. 234).

Following the state-run studies, a team of epidemiologists from Columbia University investigated the possibility of radiation-caused cancers from the TMI accident. According to Walker, "The new investigation suggested that emissions from the accident had been too low to increase the incidence of cancer within a ten-mile radius of the plant" (p. 235).

Although the validity of Columbia's study was later questioned by a team from the University of North Carolina, a study conducted in 2000 by a team of researchers at the University of Pittsburgh agreed with Columbia's findings. The University of Pittsburgh researchers surveyed a group of people who lived within a five-mile radius of the plant between 1979 and 1998 and did not find any evidence that "low-dose radiation releases during the TMI accident had any measurable impact on the mortality experience." The lead researcher summarized the team's findings and said, "When you compare observed with expected cancer, there is virtually no difference" (p. 236).

The evidence is clear but may not be as impactful to many casual viewers as the images of dead fish, the statements about having a metallic taste in one's mouth, or the frightening image of burns or boils on the skin of the young woman. Such images and anecdotes, while emotionally impactful, are not entirely truthful, however. While the explanations to these anecdotal incidents may never be known for certain, it is clear that radioactivity from the accident is not the cause.



President Jimmy Carter (front) touring the TMI-2 control room on April 1, 1979, with (from left) Harold Denton, Pennsylvania Gov. Dick Thornburgh, and James Floyd, supervisor of TMI-2 operations.

The dead fish, for example, could be an actual image of the river following the accident—but it could not have been caused by radiation, considering that all of the water samples never registered dangerous levels of radiation. Lake Barrett provided a hypothesis: "TMI-2 tripped from 100 percent power," he said, "then the water discharge temperature went down quickly, causing a shock to the temperature of the water outside the plant. That may have caused the dead fish in the river. It certainly was not radiation, as levels that high would clearly have been seen in the hundreds of samples taken then and afterward."

That some locals reported a metallic taste shouldn't be surprising; there are many causes aside from a radiation release event. The metallic taste is a common symptom associated with a host of potential causes, according to WebMD—a cold or sinus infection, indigestion, heartburn, or side effects from medication, to name a few. While the exact cause is unknown, this we do know: at TMI it was not caused by high levels of radiation.

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Finally, the image of the young girl with burns or boils on her skin naturally brings about an emotional response. The subject of the image was said to have been riding her bike around Middletown all day during the events of the accident and later had these burns all over her body. However, ANS member Amir Bahadori, an expert on radiation risks and protection, explains that skin reddening has a threshold of roughly 2 Gy (200 rem photon), which means the amount of radiation released to produce this symptom would almost certainly have been many orders of magnitude greater than the values discussed above. It is incredibly unlikely that other residents, plant staff, or NRC/industry responders would have exhibited no effects under these circumstances; there is simply no way there could be just one case of skin reddening if radiation levels were as high as *Meltdown* suggests with these images.

Hydrogen gas bubble

The second episode of the series devotes a lot of time to the hydrogen bubble—again, without relying on any of the experts involved. Instead, the showrunners turn to Richard Parks (who didn't start working at TMI until two years after the accident) and Michio Kaku (a physicist and professor at City College of New York). Here, the show revisits comparisons to Chernobyl and provides visuals of an atomic bomb explosion—statements and images that are plain wrong and irresponsible.

According to Kaku, "A hydrogen gas bubble [was] forming at the heart of a nuclear power plant with unknown consequences. Hydrogen explodes, and therefore, there was the possibility of an explosion there inside the reactor itself. This is what happened, by the way, at Chernobyl. Hydrogen gas explosion blew the entire roof of the reactor apart, leading to radiation being released into the environment." This statement alone proves Kaku doesn't actually have a clue what he is discussing, since Chernobyl was not a hydrogen explosion event—it was a criticality event followed by a steam explosion.

Walker, in an email to *NN*, said that "the greatest misunderstanding in the Netflix series about the TMI-2 accident is that the NRC feared that a hydrogen bubble in the pressure vessel would suddenly explode, blow the roof off containment, and spew huge amounts of radiation in central Pennsylvania. There was great concern about the hydrogen bubble, but no one at the NRC thought that it would suddenly, without warning, fracture the walls of the pressure vessel and breach containment."

Roger Mattson, a division director in the NRC Office of Nuclear Reactor Regulation at the time, raised the alarm about the hydrogen bubble, but the concerns arose mostly because "the situation was both unprecedented and unforeseen" (Walker, *Three Mile Island*, p. 141).

The concern surrounding the hydrogen bubble had to do with the chance of oxygen being introduced into the pressure vessel and creating an environment where the bubble might ignite. ANS member Robert Budnitz, then deputy director of the NRC Office of Research, said in the Rogovin report that the NRC commissioners wanted two groups: one to research oxygen radiolysis (to assess the chance that radiation could split the water molecules into hydrogen and oxygen) and the other to research whether the pressure vessel would fail were the bubble to ignite. The uncertainty surrounding the hydrogen bubble led NRC commissioners to consider recommending an evacuation of residents; fortunately, however, they soon realized that the hydrogen in the pressure vessel would actually suppress the generation of oxygen in the system, and the control room operators deftly degassed the system by carefully running the hydrogen through the pressurizer and make-up tank. This meant the perceived hydrogen bubble threat was not a concern and that the NRC "was chasing a myth" (Walker, *Three Mile Island*, p. 184).

Metldown's portrayal of the hydrogen gas bubble scare is a prime example of the biased and irresponsible nature of this Netflix series. Instead of focusing on the technical facts and interviewing the experts who were involved in the accident response, it stokes irrational fears of a hydrogen bomb explosion (something that cannot happen in a nuclear power plant).

Krypton gas

Staying true to its formula of providing dramatic statements without sufficient context or expert verification, the series focuses one segment on the large amount of krypton gas in the containment building. In order to begin the process of cleaning up the site, the gas needed to be removed from the containment building. Walker notes in his book that the NRC's best option was to permit the utility to very gradually vent the gas into the atmosphere while closely monitoring levels of radiation so that levels did not exceed the normal amounts nuclear plants were allowed to emit annually during normal operations.

Even the Union of Concerned Scientists, which included a veritable "who's who" of nuclear critics, agreed with this approach, according to Walker. The UCS stated in a report to the Pennsylvania governor that "removing the krypton gas was essential and none of the options would present any serious radiation hazards to the public." This event, while not serious in any possible health effects on the public, provided a chance for the series to place more doubt in the minds of viewers regarding the levels of radiation around TMI and the NRC's ability to manage the accident. The show provides clips of angry protesters and claims of "uncontrolled releases" of krypton gas, even though in reality it was a closely monitored event.

Richard Parks and the polar crane

A large portion of the final two episodes focuses on Richard Parks and the whistleblower case around the polar crane at TMI-2. The series does its best to downplay the role of the NRC and create drama where there was, in fact, very little.

During his interview with *Meltdown's* producers, Parks makes it seem like his motivations were all based on a strong safety case instead of a procedural debate. Again, the series gives a major percentage of the screen time to Richard Parks and hardly any time at all to Barrett to explain the facts of the situation.

In an email to *NN*, Barrett said that no one was arguing with Parks that the polar crane needed to be tested appropriately before the lifts. Parks was concerned with the procedures that General Public Utilities (GPU) and cleanup contractor Bechtel were submitting to the NRC for review. Barrett said that utilities normally do not do major equipment construction/refurbishment work, but, when necessary, generally used engineering change notice (ECN) administrative procedural approaches to ensure the proper quality assurance of the work. More commonly, nuclear organizations use work package procedural approaches when major engineering construction work is undertaken to ensure the proper quality assurance of the work. The actual TMI polar crane work, which required nearly complete rewiring, detailed structural confirmations, and major replacement tasks (such as braking systems), was a combination of both major refurbishment work and operations. The GPU/Bechtel management team selected the work package procedural approach because the polar crane task was major construction refurbishment work that had to be done within the challenging internal containment radiological and environmental conditions. The team believed that this approach would also ensure safety while being the most efficient.

Barrett said that both procedural approaches are capable of doing the job safely and the NRC generally accepted either procedural approach if it was proposed by the licensee. The NRC did not object to the work package approach for the polar crane and proceeded to judge each GPU polar crane work task and operating procedure on its safety merits. Both GPU and the NRC agreed that safety was first but that it was also important to move forward with the cleanup without unnecessary administrative delay. Gaining access to the damaged core to enable defueling was an important activity to reduce the unknown risks of the damaged core remaining in an unknown internal situation.

Independent of any specific safety concerns, Parks did not like using the work package approach and complained to Barrett at the NRC in a February 18, 1983, meeting that he felt that the ECN approach was the proper one to use. Barrett asked Parks what his safety concerns were, to which Parks replied only

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that he thought Bechtel was not following the procedures correctly or producing the proper calculations. The NRC performed a special surprise inspection at the Bechtel Gaithersburg office that week and determined that the calculations were properly performed. Barrett met with Parks on February 25, 1983, and told him that the safety calculations appeared satisfactory and that the NRC would continue to focus on the safety performance for upcoming refurbishment and testing tasks for the polar crane, but would not enter into licensee internal staff arguments between individuals within GPU or Bechtel about which type of procedural approach to use. The NRC's focus was on safety performance and risk reduction progress, not on internal administrative differences of opinions.

Parks did not like that answer, and he filed an affidavit appealing to the NRC commissioners. As per the meetings with Barrett, Parks's 57-page affidavit was all about administrative procedural complaints without any specific safety issue with the polar crane. Nothing that Parks claimed in the affidavit could have supported the program's claims that if Parks did not act, there could have been a second accident "that could have wiped out the whole East Coast," a possibility posited multiple times in the Netflix show. Thus, the final segments of the program are completely inaccurate and misleading.

Barrett wearing a radiation protection suit prior to going into containment for the first missile shield lift with the polar crane.

Meltdown doesn't discuss the procedural disagreement to the refurbishment of the crane. Instead, it jumps straight to a theoretical accident in which the polar crane could have failed and created a "supercriticality" event that could have contaminated much of the East Coast. Again, this is pure sensationalism and has no basis in science. There was no way for the reactor to go critical, neither could it go through another meltdown event. After four years of cooling the core, the decay heat in 1983 was about 25 kilowatts, which is equal to about 20 home hair dryers—not enough energy to melt anything large. To put that into some context, a normal operating reactor puts out over 2 million kilowatts of heat energy. More importantly, the reactor coolant had been borated to a level that effectively precluded recriticality regardless of configuration of the fissile core material geometry. (Boron is an effective neutron absorber that controls the rate of the reaction and can even slow or stop it—without itself fissioning.)

ANS past president Bill Burchill (2008–2009) was involved in the investigation of the accident at TMI-2 early on and led the response from his company, Combustion Engineering, to questions from the NRC. In 2019, Burchill revisited this when he wrote for *NN* about the accident and the many changes it forced on the industry. Burchill said in a phone call with *NN* that by 1983, "the core was never in any danger of reconfiguring itself into a self-sustaining chain reaction at this stage in the cleanup of TMI-2."

He added, "The reactor shut itself down in the early stages of the accident by dropping the control rods into the core automatically. The nuclear chain reaction was shut down within the first five seconds of the whole event and was never at any risk of returning

The cooling towers of Unit 2 at Three Mile Island Nuclear Generating Station, closed since the accident in 1979.

to a critical state. The core was not going to experience a self-sustaining nuclear reaction and it could not go off like a bomb and destroy thousands of square miles of land; that is one of the biggest falsehoods that is made in this documentary."

Meltdown is a letdown

Meltdown tries to be a legitimate documentary from Netflix Studios, and yet it emphasizes only the most dramatic moments without providing sufficient context from experts. Instead, it relies on the memories and words of local residents who did not work at the plant, antinuclear activists, and Richard Parks, who wasn't even employed at TMI until 1982. Rather than let experts in the field lead the narrative, the show tries to force a tale of greed and corporate cover-up that is not even close to reality.

The fact that the show does not mention one single subsequent change to the industry and the NRC that came about as a result of the Three Mile Island accident is absolutely maddening. Steve Nesbit said, after watching the documentary, that "the most striking failure of the show was the lack of any mention of the reaction of the nuclear industry and the NRC to the accident. The entire approach to operating and regulating nuclear power plants in the United States was transformed as a result of the accident." Within a year of the accident, the Kemeny Commission and Rogovin inquiry reports were published and explained the causes, effects, and changes needed in order to make the nuclear industry a safer source of power generation. The aftermath of the accident also led to the establishment of the Institute of Nuclear Power Operations, the goal of which was to drive the industry to high levels of excellence.

The past 40 years of improving plant performance have been coupled with enhanced safety focus provided by a risk-informed approach that focuses resources on the most safety-significant issues. Instead of stoking fears, *Meltdown* should have focused on the millions of lives saved by keeping the current U.S. reactor fleet running after the TMI-2 accident, keeping millions of tons of carbon dioxide from the atmosphere and producing more than 50 percent of the carbon-free energy in this country.

Correction issued August 2, 2022, to a statement attributed to Amir Bahadori above. The statement that skin reddening "has only been observed in victims of nuclear explosions" was included in a quote attributed to him. Bahadori did not, in fact, make that statement. Skin reddening is a reaction that has been often observed during medical procedures involving high levels of ionizing radiation exposure and in the early days of x-ray experiments. *Nuclear News* sincerely apologizes for the error.

Lake Barrett's reality-grounded perspective on Netflix's drama *Meltdown: Three Mile Island*

Barrett

In an ANS-sponsored online event held on June 8, independent energy consultant Lake Barrett shared his perspective on the Netflix docudrama series *Meltdown: Three Mile Island*. Barrett, who was the Nuclear Regulatory Commission's on-site director and senior federal official for the cleanup of the TMI Unit 2 accident in the early 1980s, countered inaccuracies in the series during an interview with ANS Executive Director/CEO Craig Piercy.

Piercy started the program by summarizing the basic events of the TMI incident, noting that Unit 2 at the site had experienced a partial meltdown of its core on March 28, 1979. The resulting small radioactive releases had no noticeable effects on plant personnel or the public. Nevertheless, he added, the accident was the most serious in the history of U.S. commercial nuclear power plants, and it prompted major reforms in the regulations of these plants.

Three Mile island in 1979.

Regarding the Netflix docudrama, Piercy said that it blends "a mix of honestly great, remarkable footage of the event and its aftermath into a dark narrative of risky cleanup maneuvers that put the, quote, survival of the East Coast in the balance." He observed, "In our algorithm-driven world, one that increasingly blurs the distinction between journalism and entertainment, shows like *Meltdown* live on in the Netflix recommendation engine and exert a hidden pull on our collective perception of history."

Piercy continued, "That's why we at ANS thought it was important to ensure that the historical record is there for everyone looking to answer the question 'What really happened at TMI?'"

Piercy and Barrett's discussion spanned topics such as whether or not there was an explosion at TMI-2, the actual measured radiation levels around the plant during and after the accident, and the misconceptions people have around radiation. They then spent a significant portion of the interview discussing the polar crane incident during the TMI cleanup since the Netflix series focused largely on this incident, through the lens of whistleblower Richard Parks.

The discussion with Piercy allowed Barrett to clear the air and explain the facts of the situation, something the Netflix series skirted in favor of drama and sensationalism. A recording of the discussion is available to ANS members and the public at ans.org/webinars/view-tmi2022/.

Nuclear FOMO

At the June ANS Annual Meeting in Anaheim, Calif., our Executive Director/CEO Craig Piercy used an interesting acronym: he said, "This meeting is so exciting we are going to give nuclear professionals FOMO with respect to ANS meetings going forward." The term "fear of missing out" was common a few years ago, but I had not heard it recently. So when Craig used it, it really caught my attention. Craig was, of course, correct that the Annual Meeting was great: technically interesting, productive, and great fun, as well. It provided a wonderful opportunity to learn, network, and advance both academic and business goals. However, in thinking about this phrase I realized that in a lot of ways, getting people to realize how important nuclear science and technology is for making the world better is a lot like trying to get people to understand that they are truly missing out.

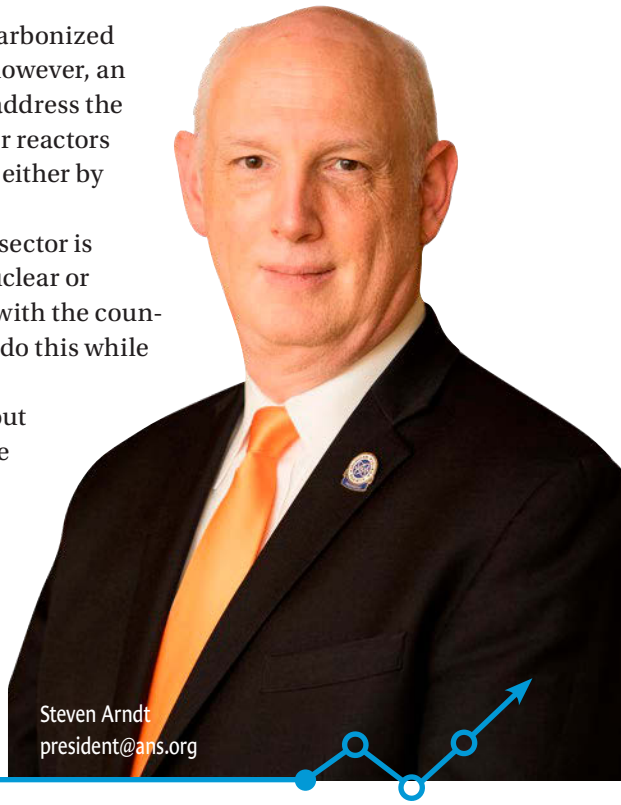
In last month's column, I talked about the importance of getting out there and being enthusiastically and unapologetically pronuclear**.** The next logical part of this is to craft a message that we want people to understand. Since my skill set is mostly in the power part of our profession, I will be using that area as an example, but we need people in all areas of nuclear science and technology crafting their message and getting it out there.

So, what are people missing out on with respect to nuclear? If the U.S. Energy Information Administration projections for energy consumption through 2050 are correct, demand for energy in both the U.S. and the world at large is going to continue to increase, driven primarily by electric, transportation, and industrial consumption. For this to occur while also maintaining reliability and availability of energy, nuclear must play an ever-increasing role. This was true before the invasion of Ukraine and is even more so today.

In addition, the role of nuclear in hydrogen production in a deeply decarbonized energy supply is critical. Hydrogen is not a primary energy source. It is, however, an important energy carrier that, in combination with nuclear energy, can address the need to decarbonize the nonelectric energy sectors. Advanced light water reactors as well as higher-temperature reactors can effectively produce hydrogen either by traditional electrolysis or by high-temperature steam electrolysis.

The use of both nuclear hydrogen and electricity in the transportation sector is critical. Until the majority of electricity and hydrogen are provided by nuclear or renewables, transitioning to electric cars and trucks won't actually help with the country's green energy goals. Nuclear is the energy source that will be able to do this while maintaining the needed high reliability and availability.

As I said earlier, there are a lot of different things the world is missing out on because it is not proactively embracing nuclear. One of them is that we need to use nuclear power to decarbonize the transportation sector, and we need to do it now, or I fear we will miss our clean energy goals. This is a kind of FOMO everyone should have.



Steven Arndt
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Nuclear Trending continues

See Position Statement #35:

See Position Statement #84:

ANS revises advanced reactors position statement and publishes new statement on HALEU

The ANS Board of Directors recently approved two position statements from the Public Policy Committee: a revision to PS #35, *Advanced Reactors*, and the completely new PS #84, *Safeguards and Security for Advanced Reactors Using HALEU*. ANS's position statements reflect the Society's perspectives on issues of public interest that involve various aspects of nuclear science and technology and are prepared by key members whose relevant experience or publications inform the documents. Prior to approval for publication, the documents are reviewed by relevant ANS committees and divisions.

Originally published in 2018, PS #35 focuses on the shared attributes of multiple advanced reactor designs. The revision to the statement adds information to the background section, updates links to references, and includes the recent progress of Department of Energy programs like the Advanced Reactors Demonstration Program.

The newest statement endorsed by ANS leadership is PS #84, *Safeguards and Security for Advanced Reactors Using HALEU*. This statement complements PS #35 by supporting the deployment of advanced reactor designs that use high-assay low-enriched uranium fuel.

To download the statements alongside their expanded background information, please visit ans.org/policy/statements/.

Nuclear Notables—Vendor and contractor ads through the decades

December 1960 The Technical Measurement Corporation offers "a complete digital computer with all the circuitry for a 256-channel magnetic core memory."

January 1985 Rad Services notes that everyone can mop floors, but not just anyone can clean up after high-radiation jobs.

January 2000 "Will you end up a have? Or a have not?" NPS Energy Services ponders "the brave new world of deregulation."

September 2021 "Making tomorrow's reactors better today": the hope of the Versatile Test Reactor.

1960 1970 1980 1990 2000 2010 2020

January 1977 Nuclear navy propulsion: "The fastest way up in nuclear engineering."

August 1992 After the job is finished, go play golf, enjoy nature, and have a snack, says Gulf States Utilities.

May 2015 The Schulz Group has had more than 30 years of nuclear experience and a "passion for piping."

Trust is the coin of the realm

It is often said that in Washington, "trust is the coin of the realm." Of course, you can be forgiven for thinking these days that trust in politics is an outmoded concept—that the only coin of the realm today is, well, "coin." But you would be wrong.

Behind the facade of political polarization and tribalism there still exists a genuine desire to make good policy. Of course, each side of the ideological spectrum will always have their preferred set of solutions, and those solutions will usually be "spiced" by the parties' respective "bases." But I never cease to be surprised by how much undetected common ground exists on practical matters.

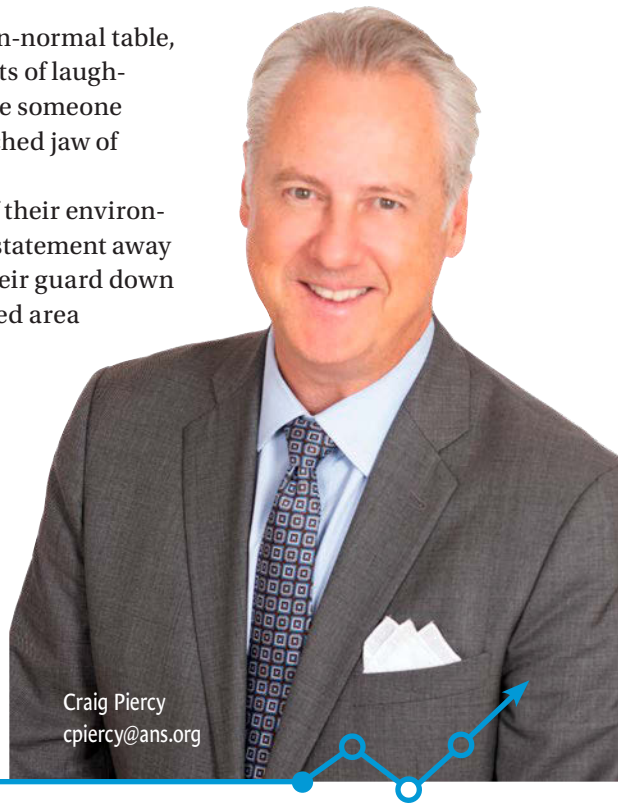
During the last six months, in partnership with the bipartisan U.S. House Advanced Reactor Caucus, I have had the honor of moderating monthly Jeffersonian dinners on Capitol Hill with members of Congress and leaders from across the nuclear profession. If you are not familiar with the format, a Jeffersonian dinner requires that there be one single conversation at the table around a posed central question, such as, "Is nuclear energy overregulated?" or "Should the U.S. recycle its nuclear fuel?"

These dinners also have a special set of rules. First, the Chatham House Rule: guests are allowed to talk about the conversation with others but cannot do so in a way that identifies the speaker. There are other rules, too: no lobbying, no peddling of wares, no filibustering (senators excepted, of course). Finally, members can stop the conversation at any time to ask a question or clarify a term.

Adherence to congressional ethics rules makes for a slightly larger-than-normal table, but it is still small enough to have candid conversation. We've also had lots of laughter, a bit of profanity, and—because we generally try to make sure we have someone with opposing viewpoints at the table—the occasional red face and clenched jaw of enforced civility.

Why do we do this? Like all of us, members of Congress are products of their environment. They are lobbied and messaged to constantly. They are one public statement away from having protesters outside their front doors. The more they can let their guard down in a trusted environment and ask basic questions about a very complicated area of science and technology, the better nuclear policy will be, regardless of the flavor.

In the past, and with typical engineering understatement, ANS would often use the phrase "providing factual, unbiased information" to describe its efforts to engage policymakers in Washington. I would describe it today as "providing facts in an unbiased context to enable better decision-making." But in the end, it's really all about trust. Trust for a nuclear professional community that deserves more than it gets.



Craig Piercy
cpiercy@ans.org

2022 ANS Annual Meeting: "The New Outlook"

The 2022 ANS Annual Meeting, held June 12–16 in Anaheim, Calif., had the theme "The New Outlook." In addition, three topical meetings were held in conjunction with the annual meeting: Advances in Thermal Hydraulics (ATH 2022), the Nuclear Criticality Safety Division Topical Meeting (NCSD 2022), and Technology of Fusion Energy (TOFE).

Speakers, panelists, and other participants at the annual meeting's opening plenary focused on the nuclear community's adaptations to post-pandemic conditions, which included disruptions of the economy and shocks in energy prices and availability, as well as steps toward deep decarbonization and advances in nuclear technologies.

Steven Nesbit, then ANS president, began the opening plenary by noting the appropriateness of holding the meeting in California, observing that the state's governor, Gavin Newsom, had announced that his administration was looking into the federal Civil Nuclear Credit Program to keep the Diablo Canyon nuclear plant in operation beyond its scheduled 2025 closure date. Nesbit stressed the importance of continued grassroots pressure to try to keep the plant open. He also discussed ANS's actions to ensure the safety of nuclear professionals in war-torn Ukraine, including the fundraising efforts of the ANS–European Nuclear Society Ukrainian Nuclear Workers Humanitarian Fund.

Steven Nesbit speaks at the opening plenary.

Craig Piercy, ANS Executive Director/CEO, picked up on Nesbit's comments about California, noting that the state may finally be "getting serious about its future" and that California officials may be ready to "get down to the brass tacks of building a clean, reliable, resilient, and affordable energy system for the future." Piercy also observed that there is "clearly a new outlook for fusion, and that competition between the fusion and fission sectors of the industry is healthy." He added that ANS is "bound by our commitment to harness the power of the atom as a force for good—whether that comes from forcing them together or breaking them apart."


Piercy

After the presentation of ANS awards and honors, moderator Per Peterson, the meeting's general chair and the chief nuclear officer of Kairos Power, addressed the attendees: "So much has changed and so much has happened over the last few years, and we really need to use this as an opportunity to recalibrate and look toward the future." In his introduction of the keynote speakers, Peterson noted that they would share diverse


Peterson

perspectives on the use of nuclear technologies in both fission and fusion for clean and sustainable energy.

Public opinion and policy: Founder and executive director of the Breakthrough Institute Ted Nordhaus, in his address, asserted that the nuclear community has a "generational opportunity to reset both public opinion and policy with regard to nuclear energy." He emphasized the need to promote the vision that "nuclear is a critical technology for the future of human societies—both to assure human thriving and to preserve the environment."


Nordhaus

Nordhaus spoke of the growing pronuclear environmental movement, which he called a "historical development" that is changing the discussion of nuclear energy. The debate over nuclear, he said, is no longer solely defined by industry and government on one side and an antinuclear movement on the other. "The single most important thing that has driven a change in the political possibilities for nuclear energy has been the emergence of this civil society pronuclear movement that has disrupted the traditional fault lines."

Further driving the change are growing concerns over climate change, a broader recognition that renewable energy sources are insufficient, and a "post-pandemic price shock" over rising energy prices. Regarding shifting opinions over nuclear, Nordhaus distinguished between public opinion and "elite opinion." Noting that the general public doesn't have a strong opinion on nuclear energy one way or the other, he said that the opinions of elites—political leaders, policymakers, and social figures—influence the broader public perception of the technology.

The bad news for nuclear is that the industry community seems to be "saddled with an antiquated and sclerotic regulator." In his opinion, the Nuclear Regulatory Commission is not prepared to license advanced reactors and is overly concerned with "theoretical risks" that are low or nonexistent rather than "observable risks." He characterized the current licensing process as "Kafkaesque."

Nordhaus also argued that the NRC and the nuclear community have been "in important ways captured by the antinuclear movement. . . . We continue to, in a bunch of implicit ways, accept the framings of the technology and risks that have been posed by opponents of the technology. . . . We talk about a safety culture [in such a way] that communicates [to the public] that the technology is unsafe."

Nordhaus urged the community to take a much more proactive approach in challenging and correcting misinformation about risks and to "stop with the jargon" when discussing nuclear issues.

NASA insight: Next at the podium was Dan Rasky, a senior scientist with NASA and chief of the agency's Space Portal Office. He recalled from his childhood the "fantastic" accomplishments and "drama" of NASA's Apollo program, before adding, "Unfortunately, it set up a structure and an operational model that made it very challenging for NASA to execute space programs successfully [as its budget declined] from the peaks of Apollo."


Rasky

NASA's budget peaked in 1965, four years before the Apollo 11 moon landing. By 1971, the space agency's budget had been slashed by 50 percent, causing an "anomalous budgetary situation" with which NASA struggled for decades. As a result, the space shuttle turned out to be "a technical success but an operational disappointment." Rasky explained that compromises in the shuttle's design, including "cut corners" and "workarounds," paved the way for the *Challenger* and *Columbia* disasters. Similar unfortunate results were seen in other NASA programs.

This negative paradigm finally began to turn around in 2005 with the start of NASA's Commercial Orbital Transportation Services (COTS) program, which streamlined the contractual process to motivate commercial space companies to develop needed capabilities and services for NASA. The development

Meetings continues

of this program was based on a strategy designed to share risks and benefits. COTS was then complemented in 2008 with the Commercial Resupply Services (CRS) program, which set up a viable business plan for NASA's private partners. Rasky said that these programs have led to many successes in NASA's commercial partnerships—including SpaceX's *Falcon* launch vehicle and *Dragon* spacecraft—while government costs have been cut "by a factor of 10."

Rasky concluded his remarks by suggesting that these experiences of NASA might hold some relevant analogies for the nuclear energy industry. Per Peterson responded to this comment by stating, "I know that we've been working to put in place the infrastructure capabilities to replicate the types of successes that NASA has had."

GAIN work: Christine King, director of the Department of Energy's Gateway for Accelerated Innovation in Nuclear (GAIN), began her remarks by explaining that GAIN was established in 2016 to provide the DOE's private partners with easy access to the resources of the department and its national laboratories. "We get up every day to imagine new ways to commercialize our fleet of advanced reactors and to innovate our existing fleet, all in service to a clean energy future."


King

As the United States moves closer to the commercialization of advanced nuclear technologies, GAIN is working to simplify the interface between the nuclear community and the DOE and national labs. "In particular, we're learning from NASA's experience with other transaction authority [OTA] to understand this mechanism and to enable future public-private partnerships as we move closer to scale." She noted that OTA is not about standard procurement contract grants or agreements and, thus, is not subject to standard acquisition laws and regulations. Rather, OTA "actually creates the platform for the flexibility that we need . . . for our future public-private projects to make us more efficient in negotiation and project execution."

As an example of GAIN's work, King cited the assistance that the agency is providing for several energy plants as they make the decisions necessary to transition from coal to nuclear.

King reminded the meeting attendees that "demonstrating the technology is just our first step. Securing our supply chain, building our engineering and trades workforce, strengthening and streamlining every process, creating bankable projects, and preparing communities to host our technologies is the work that we need to do, as well."

Fission and fusion: The next keynote speaker was Kathryn McCarthy, associate laboratory director for fusion and fission energy and science at Oak Ridge National Laboratory and U.S. ITER Project director. Noting that she has spent about half of her career in fission and half in fusion, she said, "Right now is a really important time for both of these clean energy sources."


McCarthy

McCarthy observed that fission is receiving prominent support (including from Bill Gates), while fusion is getting increased media attention. She recalled her surprise when she recently heard a commentator on the Fox News show *The Five* promoting investment in fusion and small modular reactors—the kind of positive attention that is exciting for the nuclear community.

"Why is there so much new interest in fusion?" asked McCarthy. And then she answered her own question: the benefits of fusion are worth the investment. There have been "massive advances" in simulations that have benefitted fusion technologies. Furthermore, "We're getting reactor-scale experience with ITER, which is the tokamak under construction in southern France. . . . It is now 78 percent complete." A number of things have been learned during construction of the ITER tokamak, such as technical advances related to setting new records for fusion power.

McCarthy argued that it is important for the United States to "win the race" for fusion. "We don't want to buy our fusion energy from other countries. The U.S. has historically

been in the lead on fusion, and we want to continue to be there," she said.

Regarding public-private partnerships for developing fusion technologies with commercial viability, she said, "It's going to take all different viewpoints to make this work," noting that the fusion sector is learning from the fission sector, as well as investigating the implementation of OTA, which is "really good from the perspective of getting funding to industry."

Comments on the NRC: The final keynote speaker was Kristine Svinicki, a former chairman of the NRC, who addressed Nordhaus's earlier remarks that were critical of the NRC: "We will have that dialogue here but let me just say that with regard to the core of the concerns and disconnects that Ted mentioned, we have a lot of agreement on that," she said.


Svinicki

Svinicki, who currently is an adjunct professor at the University of Michigan, knows that new ways of thinking are needed at the NRC. However, a major challenge she faced during her tenure there was related to the fact that the NRC has historically been considered to be a successful organization, and such organizations are more difficult to change than those steeped in crisis. She acknowledged Nordhaus's point about the NRC's misperception of risk but noted that there is "no incentive in the system to redefine risk . . . to do the kind of resetting on the language, on the mindsets that Ted talked about."

Svinicki confessed that, considering all the years that have already been spent talking about these problems at conferences, she feels "less confident that, given all the stipulative conditions that exist, the regulator is going to be equipped and ready to fulfill the role it needs to in order for nuclear to occupy its role in a clean energy future that it has the potential to occupy. . . . I'm not confident that the system as it exists right now can get this important regulatory role to where it needs to be on a timescale that matters to the problems that we're trying to address."

Despite her general pessimism regarding changing the NRC anytime soon, Svinicki suggested that people need to keep pushing for action: "I'm sure that 10 years from now, our successors who occupy these roles are going to be pretty frustrated with us for not moving faster than we're moving."

Grand challenges

The President's Special Session offered members a chance to revisit the Society's Grand Nuclear Challenges. Introduced in 2017 and put forth by the members and the ANS professional divisions, the nine challenges identify cross-cutting technical issues to be resolved by 2030 to help address the economic, sociological, or political concerns facing nuclear energy.

While the scope of the session could not include an examination of all nine challenges, the four panelists each took up a challenge topic for discussion as it related to their fields, sharing their views on the progress made in the five years since ANS's list was first introduced and what actions still need to be undertaken to meet the stated goals.


Bahadori

Low-dose radiation: Amir Bahadori from Kansas State University called the challenge to establish a scientific basis for modern low-dose radiation regulation the most ambitious of all the nine grand challenges—primarily because of all the conflict surrounding the regulation of low-dose radiation protection.

Bahadori said that much progress has been made in the past five years in moving toward a more informed and reasonable discussion of the linear no-threshold model of radiation risk. When it comes to the principle of "as low as reasonably achievable" (ALARA), however, Bahadori said that the concept continues to be misused as a radiation protection tool and more must be done to improve its application.

"ALARA is not minimization and was never intended to be minimization, it is optimization," he said. "It requires us to consider all the costs and benefits associated with every

Meetings continues

action taken to incrementally reduce exposure below the limit at hand."

Radioisotopes: As a senior policy fellow at Argonne National Laboratory, Paul Dickman discussed the grand challenge of ensuring the continuous availability of radioisotopes. Noting the huge role nuclear materials play across many industries, Dickman said that it is difficult to imagine a modern industrial society that does not use radioisotopes.


Dickman

He explained that since radioisotopes are in demand around the world and only a few countries can produce a steady supply, radioisotope availability continues to be an issue needing close attention. This is despite the development of new techniques by U.S. companies such as Shine Medical Technologies, which is using neutron generator technology to produce the medical radioisotope molybdenum-99.

"Russia and China really dominate this market," he said. "The U.S. program in this area is very small, and it is hard to compete with someone selling an isotope at 10 percent of what it costs you. And that is a real problem for us."

Fortunately, Dickman said, the U.S. Congress is aware of the problem, and ANS members can help keep awareness of the issue in front of leaders.

Public engagement and knowledge transfer: Alyssa Hayes, a nuclear engineering doctoral candidate at the University of Tennessee, discussed the twin challenges of public engagement and knowledge transfer, focusing on actions ANS members can take to advocate more effectively for nuclear technology and increase opportunities in nuclear education.


Hayes

"Legislators want to hear experts like you who live in their states or their local areas," she told the audience. "And I know advocacy takes time and effort, but that is why it is so important to have organized advocacy." Hayes encouraged ANS members to reach out to pronuclear groups, such as Generation Atomic, for help with the organization aspect.

She also noted efforts at the University of Tennessee and other universities to increase diversity and make nuclear education more available to underrepresented people. "The new and young generation of nuclear folks in our community is already diverse, and it is on us to ensure that they have access to all the opportunities for knowledge transfer that we have today, that they continue to have that access, and that we expand it to more people to ensure there isn't a glass ceiling for them," she said.

Rejuvenating infrastructure: As the session's final panelist, Kathryn Huff shared progress the federal government is making in rejuvenating nuclear technology infrastructure and facilities. Huff is the assistant secretary for the DOE's Office of Nuclear Energy.


Huff

When considering the roles of government and private industry in developing and deploying new and advanced reactor projects, Huff, paraphrasing the author and physicist Amory Lovins, said that the government should steer and not row.

"When we contemplate the impact of [President Biden's] infrastructure law and what it can do to rejuvenate our infrastructure for nuclear energy, the government is steering this industry, this scientific space, but it is going to take a lot more than just government dollars and government people to move this boat," she told the audience. "All of you are going to have to help row. All of you will go back from this conference and get back to your experiments, dissertations, companies, and your endeavors, and that is going to be the rowing. And we can't course correct if we are sitting still."

Nuclear innovators

If nuclear innovators are in a race to decarbonize, it is a race with one finish line—affordable, clean, and reliable

power—and many ways to get there. Over 40 fission developers and 20 fusion developers are in the running, and while attendees of the executive session "Breaking Through: Assessing the Current State and Prospects of Nuclear Innovation in the Race to Decarbonize" heard from representatives of just three of those companies, they presented very different designs and deployment approaches, aptly reflecting the broader diversity of nuclear power innovation.

Session chair Adam Stein, director of nuclear energy innovation at the Breakthrough Institute, welcomed representatives from an advanced non–light water reactor developer (Mike Laufer, Kairos Power), a small modular light water reactor developer (Jon Ball, GE Hitachi Nuclear Energy), and a fusion power developer (Michl Binderbauer, TAE Technologies). Together they explored the challenge of engineering a significant commercial scale-up of advanced nuclear technology by the end of the decade, tackling questions of cost, schedule, supply chain, regulation, and more.


Stein

The panelists: Mike Laufer is cofounder and chief executive officer of Kairos, a company with 280 engineers focused on commercializing one reactor technology—a fluoride salt–cooled high-temperature reactor that Kairos calls KP-FHR. Having chosen to develop a reactor using golf ball–sized TRISO fuel pebbles in molten FLiBe coolant, the company is now focused on proving those technologies are safe and can be built to be both affordable and reliable, Laufer said.


Laufer


Ball

Jon Ball, executive vice president of market development at GE Hitachi, described his company's goal of reducing the size and the costs of boiling water reactor technology through the development of the BWRX-300, a 10th-generation boiling water reactor design that uses 50 percent less concrete on a per-megawatt basis than a large boiling water reactor and is capable of ramping by half of 1 percent every minute. A BWRX-300 could be operational by 2028 in Ontario after the design was selected for deployment by Ontario Power Generation, Ball said.

Michl Binderbauer, cofounder and CEO of TAE, is leading a team of 300 people with the goal of developing a fusion power plant that would go to temperatures ten times the 100 million degrees needed for conventional fusion and burn hydrogen-boron fuel rather than tritium fuel, an approach he says could simplify maintenance and avoid neutron generation. Binderbauer expects the company's next fusion machine, Copernicus, to be running by mid-decade at about 150 million degrees, to be followed by another machine by the end of the decade as the company gradually turns up the heat.


Binderbauer

Schedule: "Schedules are like balloons," Laufer said. "They'll fill with time." Pushing back against schedule inflation is necessary, he said, and Kairos has an aggressive iterative schedule of design and testing. "Those goals are going to seem impossible at first, but if you don't set goals that are hard, things will stretch out."

When it comes to planning to meet regulatory requirements for commercial deployment, Laufer is trying to strike a balance between maintaining an accelerated pace of innovation and methodically documenting the company's progress with a future license application in mind. "This is the scariest type of target," he said, "because we can go too light and not be able to catch up, or we can go too heavy and drag ourselves down."

Ball explained that GE Hitachi made the choice to develop BWR technology knowing that the fuel for the reactor was already commercially available. "We've been designing

Meetings continues

new fuel types since the 1950s, and our experience is it takes 10 years to design and license a new fuel type. So having that fuel licensed and commercially available we knew was a huge accelerator to trying to bring this to market."

Binderbauer agreed with Laufer that schedules will stretch if permitted to stretch. He pointed to machine learning as a schedule accelerator for TAE. In the past, "finding maximum and minimum in some operating condition would take maybe two months," he said. "We can do that now in 20 experiments, which is a fraction of an afternoon. . . . The human can't do that, and so those kinds of things create schedule certainty."

Pleasing the customer: Every panelist recognized that customers will be shopping by price. "These nuclear systems have to have world-class safety, but if they're not economical then they're not going to be ultimately adopted," Ball said, noting that GE Hitachi has implemented a design-to-cost process.

"These nuclear systems have to have world-class safety, but if they're not economical then they're not going to be ultimately adopted."

Binderbauer said, "We were very driven early on by the idea that if we wanted to compete in the utility space, we had to have something that couldn't just be carbon-free." A fusion power plant would have to be cost-effective and maintainable, as well. "Every iteration we do an exercise where we're looking at the latest integrated data coming out and say, 'Are we still tracking the cost picture?'" If not, Binderbauer said, more innovation is needed to bring it back on track.

Laufer explained that while Kairos sees the United States as its primary market for the commercial KP-FHR, the company is currently working on its nonnuclear Engineering Test Unit (ETU) not to meet a customer contract but as a "purely internal project to prove what we can do." Next up is Hermes, a low-power demonstration reactor to be built on a site in Oak Ridge, Tenn., with cost-shared support from the DOE's Advanced Reactor Demonstration Program.

Supply chain: Kairos Power's ETU is testing vessel pump, fuel handling, and reactivity control systems with electrically heated molten salt. But beyond that, ETU is also testing the supply chain. "We knew that suppliers that couldn't deliver what we needed for a nonnuclear system had no chance of delivering it [for] the nuclear system," Laufer said, emphasizing throughout the session that Kairos is seeking schedule and supply chain certainty by using the vertical integration model exemplified by space technology company SpaceX and by seeking investors rather than vendors.

Ball said GE Hitachi has "a much different strategy" of manufacturing fuel and control systems for its designs but relying on vendors to manufacture large components. "Forgings, reactor pressure vessels are where we have probably the greatest concern of being constrained," Ball said, noting that GE Hitachi is surveying global manufacturers to understand how many BWRX-300 modules could be built in year; the company is expecting the results of that survey later this year.

Regulation: Each panelist raised distinct and differing concerns about the regulatory process. Pressure on the NRC to modernize the licensing process and provide regulatory certainty "has produced very little outcome in terms of how they're going to do things differently," Laufer said, with one notable exception: "When you come into the room and say, 'This is something that's different, but we think it's reasonable,' you have open ears, and that's really the great benefit."

Ball said his biggest concern was international harmonization of regulation. "If you think about hundreds of these reactors needed, if you have to license them individually in every country you will never make a dent in what's required for climate change. If you submit a safety analysis report to a highly credible regulator, whether it's the U.S., Canada, U.K., or elsewhere, another regulator should be able to take that and leverage it."

From the point of view of fusion developers, Binderbauer said that the United Kingdom has recognized that fusion power

options could be emerging within the next five to 10 years and has published a framework for fusion regulation. "The NRC's struggling a little bit now because they said they lack the technical expertise today to go through that, and so we're trying to work through the last year and a half . . . trying to come up with something that will let the U.S. accelerate rather than be stagnant."

The market is vast: The panelists all expect future market demand for their carbon-free technologies. Currently, "There's a fallacy in the way people look at things, thinking that solar and wind can solve everything," Binderbauer said. "Absolutely, they're wonderful sources of power where it fits. But there are also limitations. There's no world that can run on 100 percent renewables." Binderbauer said he believes that understanding is growing and creating space for all nuclear power technologies to play a role.

"I don't consider anybody here, anybody that works in the nuclear sector broadly, as competition," Binderbauer said. "I hope everybody succeeds because the market is vast and the world needs it. So, I think we have to deliver technology that is cost-effective and scalable. And if we do that and it's reliable, it will get adopted."

Fusion outlook

A "bold decadal plan" to accelerate fusion research, development, and demonstration in partnership with the private sector emerged from a March 2022 White House Fusion Summit and inspired the executive session titled "The New Fusion Outlook."


Hsu

Moderator Scott Hsu, who is leaving a role as a program director for the DOE's Advanced Research Projects Agency–Energy (ARPA-E) to become a senior adviser to the DOE's undersecretary for science and innovation as well as lead fusion coordinator for the DOE, ably led a panel of fusion stakeholders representing universities, national laboratories, private fusion companies, and public policy and communication. The discussion intended to bring attendees with fission experience up to speed on the rapidly accelerating area of fusion energy and explore how the fusion energy community can work toward a unique path for fusion energy regulation and public engagement.

The nation's plans for a fusion pilot plant are spurred by clean energy goals and by "truly significant breakthroughs that occurred last year that required decades of public investment to get to that point," Hsu said. "The achievement of hotspot ignition on [the National Ignition Facility] and the demonstration of a 20-tesla fusion-scale magnet using high-temperature superconductors—these are trajectory-altering accomplishments."

The panelists: Hsu introduced five panelists in turn, beginning with Troy Carter, a professor of physics at the University of California–Los Angeles, who recently helped lead the DOE Fusion Energy Sciences Advisory Committee's development of a 10-year, community-led strategy for fusion development. "It's time for fusion," Carter said, noting recent scientific progress, advances in technology, and investment in the private sector.


Carter

Oak Ridge National Laboratory's Kathryn McCarthy has worked in both fission and fusion and said, "It truly is all-of-the-above in terms of clean energy solutions."


McCarthy

Artem Smirnov is chief technology officer at TAE Technologies, a company that was spun off from the University of California–Irvine in 1998 and is working on an aneutronic-fueled fusion concept that has attracted about $1 billion of private capital using a payment-for-milestones framework.


Smirnov

Meetings continues

Meetings

Satoshi Konishi, cofounder and chief fusioneer of Kyoto Fusioneering, turned to private industry after about 20 years of national laboratory research in Japan and another two decades in academia.


Konishi

Rounding out the panel, Jane Hotchkiss is president of Energy for the Common Good, which hopes to boost public policy and public enthusiasm about fusion technology. Hotchkiss spent about 30 years promoting the adoption of renewable energy technologies—and faced skepticism about the feasibility of wind and solar technologies early in her career. "That's not a bad history to have when we start with fusion—where it is now and where we hope to move it over the next decade," she said. Fusion "has a story to tell" and "has almost no identity in the public space right now."


Hotchkiss

Climate imperative: All panelists agreed that climate change mitigation goals are fueling fusion energy goals.

"We need to act," Carter said. "If you have a goal of decarbonization by mid-century, the White House summit is urging us to act quicker. We need to set up these programs. We need to start conceptual design activities around fusion pilot plants right now, and those design activities will now establish the framework for identifying technical gaps that we have to work on in parallel to get the facilities going."

McCarthy made it clear that the recommendation that the U.S. have a fusion pilot plant operating on a 2035 to 2040 timescale was based on commercial feasibility, not technical feasibility. "That date was set specifically by talking with utility representatives, who said if you want us to consider [fusion] in our transition to clean energy, that's the date where you need to have an operating commercial plant," she said. "It was not based on technical feasibility, but we did look at the technical feasibility and felt that it was possible to meet that timescale."

Hotchkiss said that she believes that climate and energy delivery needs will mean that "the practical future of energy . . . is going to be more driven by fusion in the future than any of us imagined—but don't tell any of my colleagues in wind and solar because they would immediately kick me out!"

Technical barriers: McCarthy noted that the DOE refocused its fusion energy program on fusion energy sciences a couple of decades ago and at the same time narrowed the number of concepts that were being considered and researched. Today, McCarthy emphasized, the plasma confinement method for a future pilot power plant has yet to be chosen. "Is it going to be a tokamak? Is it going to be an inertial fusion? Is it going to be a stellarator, is it going to be a reverse-field configuration? We don't know yet, and so it is important that investments are going on in all these different areas."

Smirnov said that while "a lot of technological development needs to be done in the field in general," at TAE, "we certainly took it to heart from the early days and pursued the development of all the supporting technologies really needed to make this approach cost-competitive and viable and enable the practical engineering. For us, the remaining problems to address are more in the realm of developing robust supply chains."

Konishi sounded a note of concern, saying that the situation of fusion development is "very serious" and that more attention needs to be given to materials science and engineering. Konishi suggested that in some national research programs, "You are doing science, only very small pieces, or you are doing just simulation, but nobody makes just a chunk of the steel. So that technology is lost already."

Hsu, who will be responsible for helping to resolve some of these concerns in his new role at the DOE, said, "I think we need to solve a lot of our materials challenges possibly even at the first phase of a pilot-scale demonstration. But of course, we also need to accelerate the test facilities that will help us screen the likely candidate materials, so we have to think about a different paradigm of getting to the pilot demonstration. You're not

going to solve every problem ahead of time."

Nontechnical barriers: When the panelists were asked what nontechnical barriers to fusion energy need to be tackled first, several noted the importance of building a workforce and integrating the principles of diversity, equity, and inclusion.

Carter, the only university representative on the panel, emphasized training and workforce development and suggested that private-public partnerships could help build the infrastructure needed for technical development. "We have facilities that we need to get going, test facilities and the like, and the [DOE] Office of Science has a certain procedure for doing so, which often is quite slow," he said. "If you really want to make an impact on a decadal timescale, we've got to find a new way to do business, and perhaps by a partnership we could find a way to build the needed facilities."

McCarthy pointed to economics. "I think that our biggest barrier in fusion is cost-competitiveness," she said. "We need to look at that from the beginning. It is not a low bar. So let's understand where our costs are. How do we reduce them? Because it is necessary in order to compete."

At TAE, Smirnov said, "Our approach to ensuring continuing financeability is technology spinoffs," including accelerators built for cancer treatment. Looking ahead, TAE is interested in ensuring that public-private partnership models that may emerge from federal investments in a fusion pilot plant offer a "really robust regime" for intellectual property treatment of private companies.

Hotchkiss believes that "we want to translate fusion from an academic and research space into a commercial supply space now," and she agreed that medical technology applications such as TAE's send a message about fusion companies that says: "We're self-reflective. We understand the energy markets we're moving into and we're solving some of the problems that exist today with things we've developed while we focus on the bigger picture of power generation."

Hotchkiss urged the panelists and attendees in the fusion field to inform the public about their technologies. "A 'black box' can be interpreted in whatever way the individuals—in this case I'm thinking about largely opinion leaders and stakeholders—are going to see it. Let's open it and explain what fusion is and what we want it to be," she said. "Some would call it the soft side, some would call it the forward-thinking side, but in the end, these are the people that make the decisions about how much money is allocated to DOE to fund research and how much money is going to be allocated to a public-private partnership."

Lessons learned: When the panelists were asked what the fusion community could learn from fission energy, McCarthy had a ready answer. "We should learn from how the fission industry regulates, which in a way stifles innovation. We want to avoid that." McCarthy also mentioned that a 90 percent average capacity factor is being targeted for viable fusion power plants and suggested that tools such as online monitoring that have helped U.S. fission plants regularly achieve capacity factors above 90 percent could be integrated into fusion power plants from the outset.

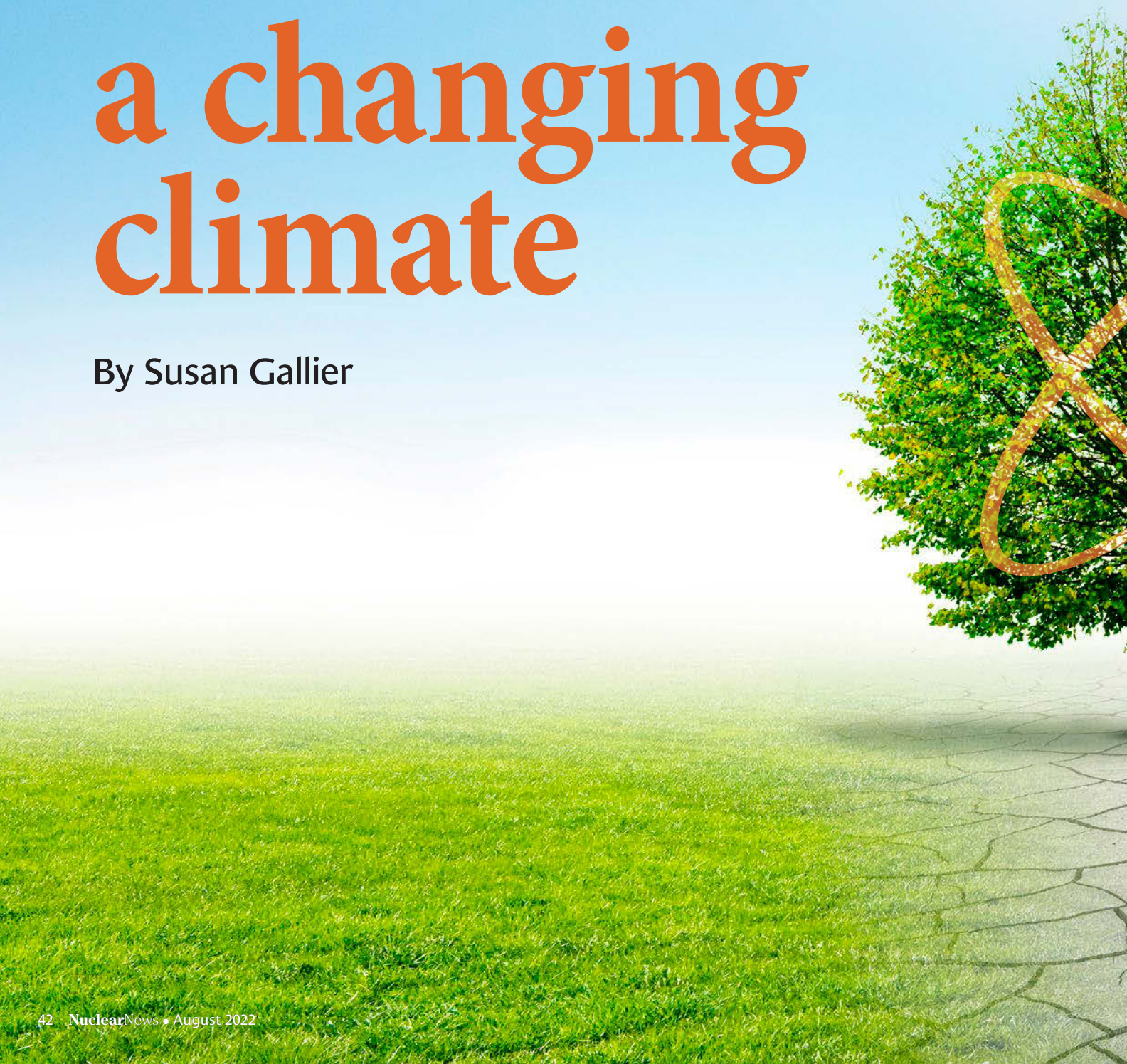
"The only way for fusion and fission to supersede each other is largely going to be determined by economics and market constraints or advantages."

The panelists were asked by an audience member if they foresaw fusion superseding fission or coexisting in the future. "I see the two as very much coexisting," McCarthy said. "I talked about the need for clean energy solutions for all different sectors—transportation, industry, and electricity—and it really is going to require a diverse set of clean energy options."

Hotchkiss agreed, suggesting that "the only way for fusion and fission to supersede each other is largely going to be determined by economics and market constraints or advantages. Quite frankly, that's a happy problem to get to."—*Susan Gallier, Tim Gregoire, and A.J. Smuskiewicz*

Nuclear power resilience in a changing climate

By Susan Gallier



All 92 U.S. power reactors operating today need water—in the right place and at the right time. But extreme weather events, including floods, droughts, hurricanes, and heat waves, upend expectations and demand resilience: the ability to anticipate, accommodate, and recover from adverse impacts.

Resilience was built into today's nuclear power plants decades ago. Weather data and climate forecasts not available then can be factored into risk analysis now to ensure the plants remain resilient in a changing climate.

Moving target

Because large light water reactors need a source of cooling water, climate and hydrology have been part of nuclear power plant planning and regulation from the beginning. What is changing are assumptions about the stability of site-specific data over time. As a November 2021 Nuclear Regulatory Commission report on estimating probable maximum precipitation puts it, "Over the last few decades, studies have produced evidence that the climate at global to local scales has become *nonstationary*, with the climate signals clearly showing an increase in ambient temperature" (emphasis added).[1]

The *State of the Global Climate 2021* report, released in May by the World Meteorological Association, confirmed that the past seven years, 2015–2021, have been the warmest seven years on record.[2] Greenhouse gas concentrations, ocean heat, and global mean sea level all hit new record highs in 2021.

The warming climate is defying the expectations set by historical data. And because warmer air holds more moisture, global warming increases the likelihood of extreme storms. According to the most recent *Climate Science Special Report* from the U.S. Global Change Research Program, "Extreme precipitation events are generally observed to increase in intensity by about 6 to 7 percent for each degree Celsius of temperature." The research program has "high confidence" that "the frequency and intensity of heavy precipitation events are projected to continue to increase over the 21st century."[3]

Water in abundance from flooding or storm events could pose a safety risk, while drought and increasing temperatures are more likely to threaten operational efficiency. The challenge of measuring the risk of climate change is in its potential for impacts that are pervasive and long term but nearly indetectable in the short term, such as temperature and sea level rise, as well as impacts that are rare, short term, and severe, such as storms and flooding. Because gradual climate change effects can worsen and increase the likelihood of extreme events, the two are closely linked.

Continued

Licensing in a changing climate

The NRC's Process for the Ongoing Assessment of Natural Hazards Information was developed from a staff recommendation to track and evaluate new information related to external hazards after the Fukushima Daiichi accident in 2011. Climate change is one of several hazards addressed by this process.

"Staff works to ensure that new natural hazards information is collected from a variety of sources and is included as part of a natural hazards knowledge base and is considered in licensing decisions," NRC spokesperson Scott Burnell told *Nuclear News*. "To date, the safety significance of new natural hazards information has been low enough that staff has not taken any regulatory actions. If new information indicates a safety concern, staff will refer that concern to the appropriate regulatory programs for detailed assessment and further action. This includes plant-specific assessments and regulatory action through the 50.54(f) process, the Generic Issues Program for something affecting a larger group of plants, or identification of the need for further research."


U.S. Army Corps of Engineers (Omaha)

Flooding

A flood warning was in place for 84 days at **Fort Calhoun** in 2011. The plant was restarted nearly three years later, only to shut down for good in 2016.

Extreme weather


Nextera

In 2020, the strong winds of a derecho at **Duane Arnold** led to a loss of offsite power and the early shutdown of the boiling water reactor in Iowa.


FPL

Sea level rise

At **Turkey Point** in southern Florida, safety-related equipment is flood protected to 22 feet above sea level for maximum predicted storm surges and wave run-up.

Cooling water impacts


NRC

Some inland plants that use freshwater cooling have been forced to reduce power due to low water levels or—as at **Browns Ferry** in Alabama—high water temperatures.


Wikimedia Commons

Drought

Staff at Arizona's **Palo Verde** plant are seeking new sources of cooling water and water conservation measures to combat drought and increased local demand for water.

Some recent NRC reports and draft guidance include discussions of the potential future impacts of climate change. A draft regulatory guide on design-basis floods (DG-1290), released in February, acknowledges the difficulty of translating global climate research findings into practical applications for specific hydrologic design problems—especially when the predicted effects have not yet arrived—noting that "the full response to a given level of global warming may take 20 to 25 years."[4]

The NRC is preparing to license new reactors—including but not limited to non–light water reactors and microreactors—that could offer climate change resilience by design. Typically smaller and operating at higher temperatures, often with liquid metal, molten salt, or high-temperature gas as the primary coolant—advanced reactors are candidates for passive cooling and air cooling methods. With no need for a large supply of cooling water, these reactors could be sited away from bodies of water, potentially reducing the threat of flooding or hurricanes.

As for the future-focused scope of subsequent license renewal for today's operating plants—and

the NRC's decision earlier this year to require SLR environmental analysis beyond the generic environmental impact statement for license renewal—it is not yet clear whether climate change will be explicitly analyzed in future SLR environmental reports. According to Burnell, "The staff continues to follow the Commission's direction concerning generic environmental issues for subsequent license renewal applications, so questions in that area remain open until the staff completes its work."

Risk and efficiency in a changing climate

The NRC doesn't regulate efficiency, but the Electric Power Research Institute (EPRI) is taking on the types of climate change impacts that nuclear power plants may be more likely to experience in the future. Fernando Ferrante, principal program manager for the Risk and Safety Management Group in the Nuclear Sector at EPRI, delivered a presentation, "Observations on Extreme Weather and Impacts on Nuclear Power Plants," during the NRC's Regulatory Information Conference session on extreme weather events in March 2022.[5]

"No site is going to have a single or unique homogeneous impact with climate change," Ferrante said. He shared EPRI analysis of weather-related operating experience from 2010 to 2020 that recorded a total of 384 days of production lost to 120 weather-related events, including grid impacts, in the U.S. fleet. Storms and high winds were most frequently implicated, accounting for more than half of the days of lost production. All told, 384 days of lost production amounted to less than 0.1 percent of generation lost to weather-related events.

"At this point we haven't seen the margins be significantly exceeded," Ferrante said, adding that while a plant might operate safely through extreme events, "Loss of generation is still something that can be a concern in terms of understanding risk. It's still risk analysis, and it's still understanding what the overall risk currently and potentially in the future is."

EPRI wants nuclear plant operators to know that plant hazard evaluations based on historical data may no longer adequately anticipate future conditions. A research project called "Anticipating Climate Change Impacts to Nuclear Power Plants: Site-Specific Climate Hazard Information and Projection," starting this year, offers site-specific estimates of key climate-related variables over the operating license based on latest generation climate model projections.[6]

Adapting to a changing climate

Oyster Creek, a 625-MWe (net) boiling water reactor on the coast of New Jersey, closed in 2018 after more than 48 years of operation because Exelon Generation opted not to invest in a new cooling system to reduce the heat discharged from the plant. While Oyster Creek's closure was an economic decision not explicitly linked to climate change, other plants are likely to face similar choices in the future.

While upgrades required for safety force a plant to choose between compliance and closure, utilities have a third choice when it comes to non-safety-related risks of lost production or reduced efficiency: they can opt not to upgrade. The decision to invest in optional upgrades is an economic one that might include an assessment of electricity market conditions and the expected return on investment over the lifetime of the plant. The potential impacts and severity of climate change—both safety and economic—could determine whether a plant invests in technological fixes, accepts the potential production or efficiency costs of inaction, or decides to close.

Cooling options

U.S. reactors with open, or once-through, cooling systems withdraw water from a lake, river, ocean, or cooling pond and typically return it to the source a few degrees warmer. While the 36 U.S. reactors that rely solely on once-through cooling were responsible for 61 percent of all nuclear plant water withdrawals by volume in 2020, according to U.S. Energy Information Administration (EIA) data, they accounted for only 3 percent of water consumption. Closed cooling systems that use cooling towers—either natural draft or mechanical cooling—withdraw less water than once-through plants but consume more by releasing it to the atmosphere as steam rather than returning it to its source. Forty-four U.S. reactors with closed cooling systems were responsible for 26 percent of nuclear plant withdrawals and 87 percent of water consumption in 2020. The 12 U.S. reactors that use a hybrid mix of once-through and closed cooling systems have water withdrawal and consumption intensity rates (measured in gallons/MWh) that predictably sit between the intensity rates for both once-through and closed systems.

At inland plants where water availability and temperature are top concerns, mitigation options include modifying cooling water inlets to access cooler water, using more efficient pumps and heat exchangers, and

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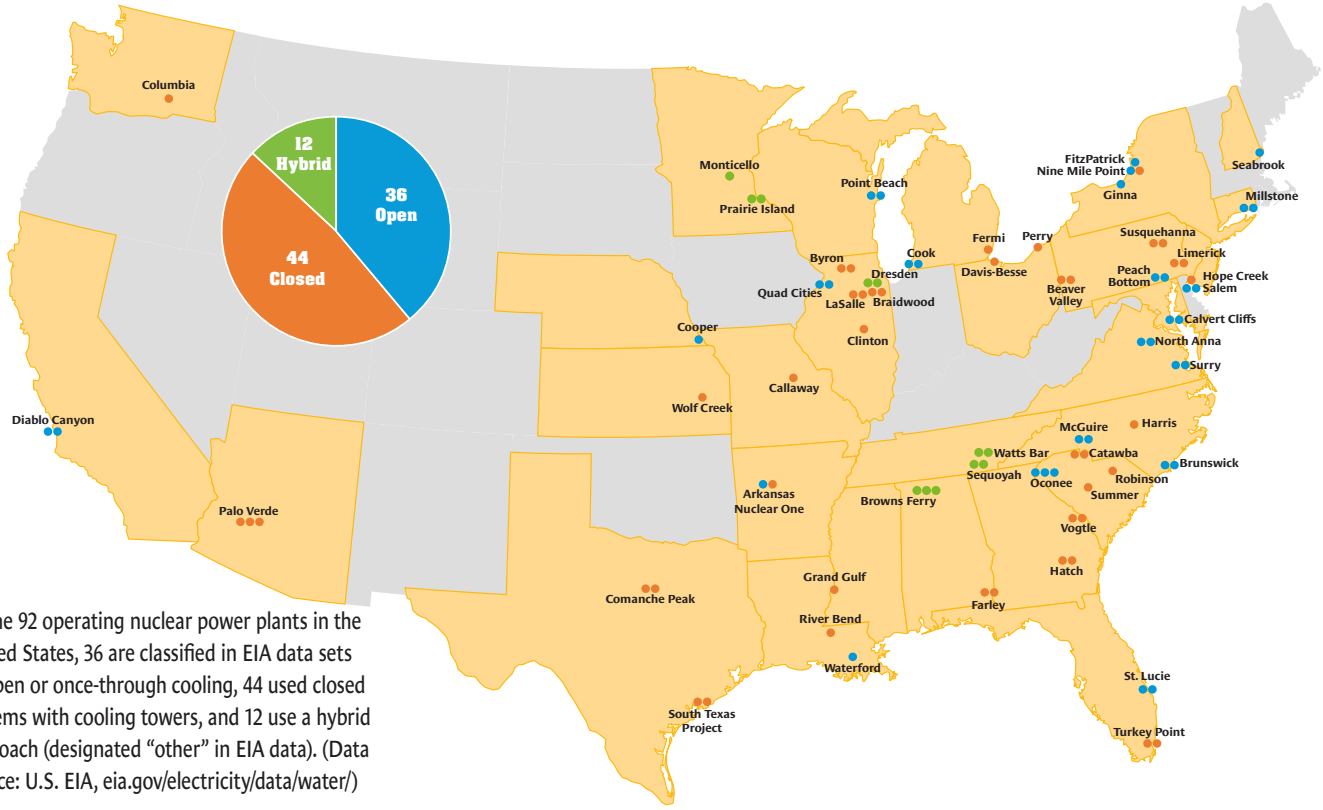


Of the 92 operating nuclear power plants in the United States, 36 are classified in EIA data sets as open or once-through cooling, 44 used closed systems with cooling towers, and 12 use a hybrid approach (designated "other" in EIA data). (Data source: U.S. EIA, eia.gov/electricity/data/water/)

adding or upgrading cooling towers. Having mechanical draft cooling towers on standby can allow plants to supplement once-through cooling when high temperatures or low water levels would otherwise force the plant to reduce power.

All three boiling water reactors at Tennessee Valley Authority's Browns Ferry plant near Athens, Ala., are operating with 14.3 percent extended power uprates approved in 2017. Those uprates mean about 15 percent more heat is being sent to the condenser while Browns Ferry's ultimate heat sink (UHS)—the Tennessee River—records rising temperatures.

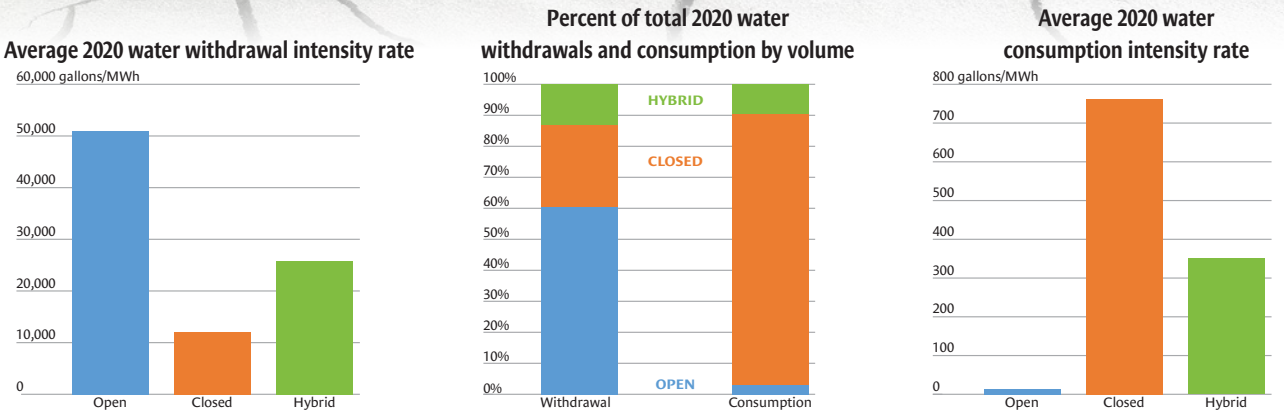
Browns Ferry's once-through cooling system gets help from mechanical draft cooling towers when the plant's operation and ambient conditions would bring river temperatures close to permitted limits. When those cooling towers cannot keep temperatures from approaching the limits, TVA must reduce the power of one or more units. In 2020, TVA produced a final environmental assessment for cooling tower capacity upgrades, including the replacement of cooling towers 1 and 2, the oldest of Browns Ferry's seven cooling towers.[7]

"Our primary goal is to avoid the potential of derating the units by restoring existing capacity and upgrading as necessary," TVA spokesperson Jim Hopson told *Nuclear News*. "Cooling tower 1 is currently operational. We have plans in place to return cooling tower 2 to operation within the next few years. We consider the current cooling towers, combined with our existing restoration and improvement efforts, to be the best match for our needs at Browns Ferry at this time."

ANS has a standard for that

The American Nuclear Society recently published a standard for the selection and use of meteorological data and supporting hydrologic information to determine whether the design water temperature and cooling capacity requirements for the UHS at a nuclear generating facility are adequately determined. ANSI/ANS-2.21-2022, *Criteria for Assessing Atmospheric Effects on the Ultimate Heat Sink*, identifies "a continued need for life-of-plant monitoring and tracking of UHS water temperatures to identify and address any degrading performance of the UHS system, in order to provide sufficient cooling capacity to handle changing environmental conditions now and in the future."[8]

ANS has two other standards that are sensitive to climate change issues: ANSI/ANS-2.3-2011 (R2021), *Estimating Tornado, Hurricane, and Extreme Straight Line Wind Characteristics at Nuclear Facility Sites*, and ANSI/ANS-2.8-2019, *Probabilistic Evaluation of External Flood Hazards for Nuclear Facilities*.



The amount of cooling water withdrawn and consumed by a nuclear plant depends on the type of cooling system it uses. U.S. nuclear power plants withdrew a total of about 20,178 billion gallons of water in 2020 and consumed about 260 billion gallons. (Data source: U.S. EIA, eia.gov/electricity/data/water/)

Proving resilience

The North American Electric Reliability Corporation's summer reliability forecast for 2022 warned of drought conditions in the Missouri River Basin that could lead to reduced output capacity from thermoelectric power plants.[9] Cooper, a 810-MWe (net) boiling water reactor in Brownville, Neb., is the only nuclear power plant that uses the Missouri River for once-through cooling, but Dan Buman, director of nuclear oversight at Nebraska Public Power District, is both prepared and optimistic.

"The team at Cooper Nuclear Station works closely with the Corps of Engineers, [which] manages the Missouri River and constantly monitors the water needs of CNS and other stakeholders along the river," Buman said. He explained that the plant was designed to operate within a water level margin of 37 feet. "Given the existing flows in the Missouri River, the amount of water storage upstream, and the projected flows through the rest of the year, the team at Cooper Nuclear Station does not currently foresee any issues with water levels in the Missouri River impacting plant operations through the remainder of the year."

Cooper has already demonstrated resilience under high-water conditions. The plant sits about 100 miles downriver from Fort Calhoun, on slightly higher ground. In 2011, while Fort Calhoun suffered physical damage from prolonged flooding, Nebraska Public Power District declared a notification of unusual event, installed flood barriers, and kept Cooper safely operating at full power.

At Cooper or any other operating nuclear plant, weathering a single severe event can't guarantee future resilience. Resilience must be proven daily by plant staff who combine reliable operation with a realistic assessment of future risks.

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

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Next for nuclear:

By Matt Wald

Can nuclear power plants prosper in the grid of 2030 or 2035, when new wind and solar farms will make electricity prices even more volatile? Can plants install energy storage that will help them keep running at full power, 24/7, to ride out times of surplus and sell their energy only when prices are high?

Quite possibly, according to a report from the Department of Energy's Idaho National Laboratory. But that energy storage may not be in the form of batteries—at least not what most people think of as batteries, according to researchers. More likely, the energy will be stored as heat, which can be used hours or days later to generate steam and then electricity. Or the energy may be stored as hydrogen, made with electricity plus heat from a reactor, which can be stored in tanks or underground caverns and converted back into electricity when the grid has greater need.

Already with only modest levels of wind and solar generation on the grid, negative pricing is turning into a problem for reactors operating as baseload plants. Free electricity may sound good to consumers. The reality, however,

Energy arbitrage

Research being done at INL's Energy Systems Laboratory is providing information on how nuclear power plants can contribute to effective energy storage and discharge, to aid in arbitrage. (Photo: INL)

is that they do not see the full magnitude of pricing fluctuations and instead pay relatively stable retail rates. For generators that can't vary their output easily, negative pricing can be detrimental.

When prices fall, the response by the manufacturer of most other products would be to make less. Although reactors are developing procedures to do this in a limited way, it is hard to do, and it does not help nuclear economics. "It does not reduce plant operating costs; instead, it increases the cost of nuclear-sourced electric power ($/MWh) as the fixed costs of operations are allocated to a lower production base," according to the authors of the report *Energy Arbitrage: Comparison of Options for Use with LWR Nuclear Power Plants* (INL/EXT-21-62939). "Nor does it represent full asset usage from a capital investment standpoint."

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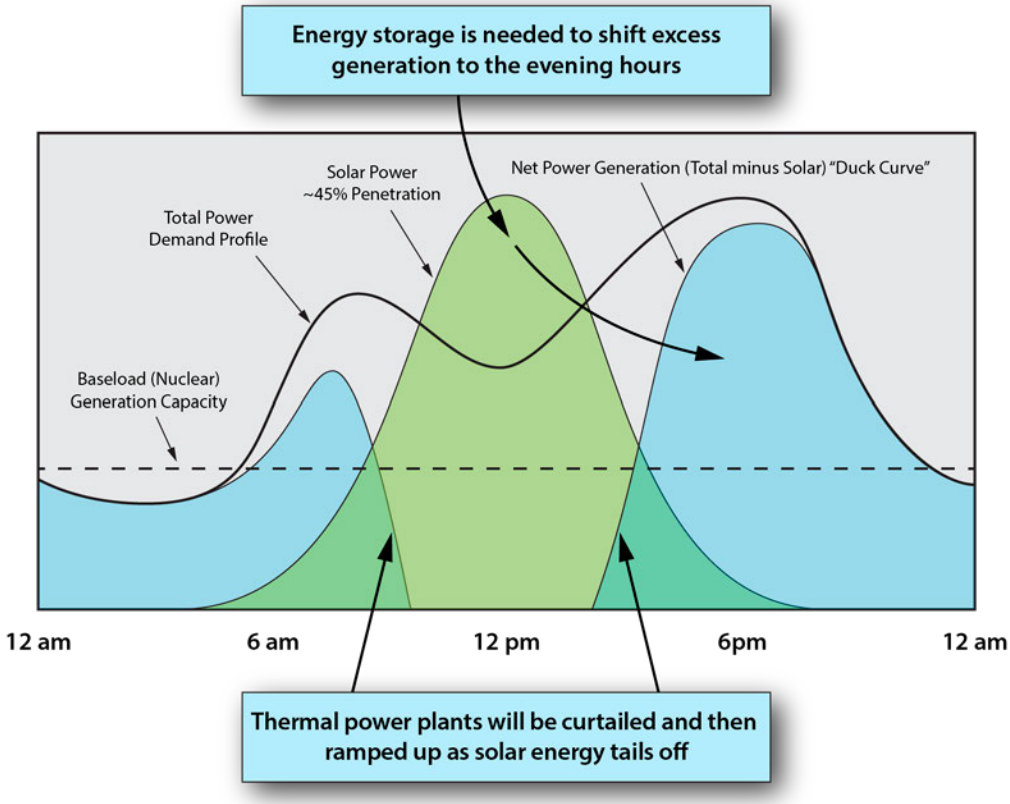


The consequences of excess solar power generation. (Source: INL/EXT-21-62939)

With great power comes great volatility

The study, produced as part of the DOE's Light Water Sustainability Program, is an effort to address a problem already cropping up in scattered locations, but which will grow with the expansion of solar and wind generation. On cool days in spring, a surplus of solar power pushes Western electricity prices below zero. On blustery but mild nights on the western side of the nation's largest power market, PJM Interconnection, wind can do the same. A negative price is the system's way of telling generators to shut down, but nuclear plants can't do that easily. Boiling water reactor operators can change the settings on their recirculation pumps to increase the void fraction, which will cut power production, and pressurized water reactor operators can insert control rods and change the concentration of boron, a neutron absorber, but the procedure is cumbersome.

Even when they do cut production, there are drawbacks: "If they're operating at 70 percent capacity, that's lost energy," said Daniel Wendt, a research engineer at INL and one of the report's authors. To meet state- and federal-level goals for cuts in carbon emissions, the system needs all the zero-carbon energy it can get.

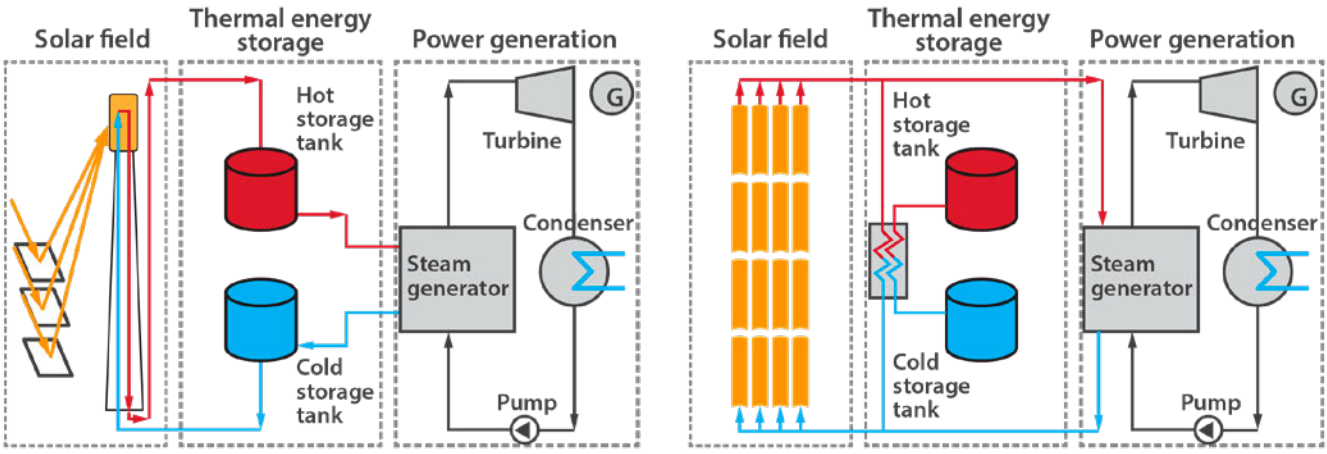
Wind and solar plants, on the other hand, do not need to shut down, because their marginal cost of generation is close to zero, and they can earn a production tax credit that makes them profitable even if they have to pay to put their generation on the grid, which is what happens when prices are negative.

Prices sometimes vary from below zero to a level two or three times the typical price (which can happen when renewables are unavailable). This opens up an opportunity for energy arbitrage, where energy could be stored when electricity prices are low and sold when they are high to increase revenue. Opportunities for energy arbitrage can be region- and market-specific, as the report's authors point out.

Weighing storage options

Energy Arbitrage, published in September 2021, seeks to rank storage technologies by cost. The calculation is complicated, because it is affected by the amount of energy to be stored, the capital and operating expenses, and the duration. Lithium ion and other battery chemistries work well if intervals are short and energy quantities are small. But storing heat works well if the cost of the system to hold the heat, and then make steam and spin a turbine generator, can be amortized over many megawatt-hours. The same is true of the electrolyzers that make hydrogen or the fuel cells or gas turbines that can turn it back into electricity.

Another factor is the round-trip efficiency, which is a measure of how many megawatt-hours you have to put into the system to get one megawatt-hour out. All storage systems are like leaky buckets, but they vary widely. For hydrogen, round-trip efficiency may be as



Solar power tower and parabolic trough concentrated solar power systems with integrated thermal storage systems. (Source: INL/EXT-21-62939)

low as 30 to 50 percent; for lithium-ion batteries, efficiency is in the high 80 percent range.

The study analyzed media for storing heat, hydrogen stored in caverns or tanks and converted back into electricity by a fuel cell or a gas turbine, and lithium-ion batteries. Among the variables analyzed for a given power output capacity were the price per megawatt-hour at which the system would be charged and the number of hours that the system could then discharge at full power level.

For an assumed system with a power level of 500 MWe, delivered for 12 hours, it found that a thermal system storing heat in a fluid called Hitec (a nitrate/nitrite salt already used in the solar thermal industry to carry heat to a steam generation system from mirrored troughs in the sun) could do that for $54 per megawatt-hour, if it charged up when the price of electricity was zero.

A lithium-ion battery system could do the same work for $322 per megawatt-hour. The lowest cost hydrogen system used tanks and a proton exchange membrane electrolyzer and burned the gas in a turbine (probably in a blend with pipeline methane). It had an estimated cost of $71 per megawatt-hour.

While the study looked carefully at storage technologies, it did not explore all of the considerations that a utility or grid entity would have to consider, nor did it explore the alternative uses for hydrogen as a product. Product uses for hydrogen, such as blending into pipeline gas for use in power plants or home heating systems or for industrial use, is the subject of ongoing research studies at INL. It could also be used in cars, trucks, or trains powered by fuel cells or in production of "green steel," where it would replace natural gas. Better yet from a climate standpoint, it could be a substitute for coal.

In all those roles, benefits would include the value of the unused fossil fuels and the value of the carbon not emitted. And utilities that serve well over half the electrical load in the United States have set ambitious carbon reduction goals for themselves, or the states where they do business have done so. In some cases, it is both the utility and the state that have such goals.

Opportunities for further research

Asked if surpluses and negative pricing could enter into a decision to use excess electricity to make hydrogen instead of curtailing a reactor's output, L. Todd Knighton, another author of the report, said, "Possibly, but the decision would be market- and region-dependent."

An additional research question left for another day is market response to the addition of large energy storage systems and the role of storage in correcting upside-down electricity markets. For example, if the system price hit minus $15 per megawatt-hour in a local market, adding a storage system with a capacity of 6,000 megawatt-hours (500 MWe for 12 hours) could push prices above zero, perhaps substantially, because diverting energy to charge the storage system would change the supply/demand balance. If storage installations are large enough, they could reduce or eliminate the volatility that they were built to exploit and profit by.

An additional consideration is what energy source the storage would be tied to. Lithium-ion batteries, whether located adjacent to a reactor or somewhere else on the grid, are simply storing grid electricity. Sometimes energy storage systems are charged up late at night when customer demand is low, by coal plants running extra hours. The storage is discharged

Continued

during peak demand periods. This may save the utility from having to build another power plant, but it also increases carbon dioxide output, because coal is dirtier and storage is inefficient. Batteries adjacent to a solar or wind farm may play an entirely separate role, switching from charging to discharging and back every few seconds or every few minutes to smooth out the production profile. Production curves that are smoother are more valuable to the system, a consideration that will grow as the inventory of variable renewable generators grows. This is still energy storage, but it addresses the variability of solar and wind generation across a few seconds or minutes, not across all the hours of the day.

Nuclear plants have advantages when producing hydrogen over some other forms of generation, the study points out. One is the ability to use heat from the nuclear reactor in high-temperature steam electrolysis (HTSE). HTSE is potentially much more efficient than conventional low-temperature electrolysis (LTE) systems. LTE could be tied to any grid electricity and would require approximately 50 kilowatt-hours to make a kilogram of hydrogen, but if hydrogen is produced via HTSE, the electrical requirement is less than 40 kilowatt-hours per kilogram. A utility could also install HTSE equipment at a thermal solar power plant or a steam-electric plant that runs on fossil fuels, but the fossil plant production would not have the benefit of cutting carbon emissions.

Of course, a company that wanted to build an HTSE system could provide the heat with electricity from resistance heat or a heat pump. But that pathway would take the efficiency hit of using heat made from electricity in order to use electricity to make heat. Using a steam turbine of a typical baseload fossil fuel or nuclear power plant, roughly 33 percent of the thermal energy is converted to electricity. It's far more efficient to borrow a little steam from the secondary side of a PWR to use as the heat source for HTSE.

"If you've got excess capacity, and if you could use that heat directly, instead of taking the hit of converting it to electricity first, that's a big win," according to Knighton. But it also requires getting regulatory approval for changes to a nuclear facility to allow heat diversion from the turbine generator, which is a cumbersome process, he said. In theory, a BWR or a PWR could be used, but the PWR represents "the lower-hanging fruit." This is because the steam used to drive a turbine at a PWR is clean. It is using water that is cleaner than tap water. But in a BWR, the steam is made from water that has passed through the core and has trace amounts of radioactive materials. It would require more intermediate heat exchangers and equipment to use this heat in an electrolyzer.

The decision to install energy storage equipment, like making hydrogen from surplus energy, also involves a calculation of the typical swing in regional energy prices at the time that a storage system would come into service. And the charging and discharging would tend to raise the trough (the low point on the variable electricity grid market price curve) and lower the peak.

Results, the researchers say, will vary by region and market. Developers of advanced reactors have taken different approaches to the variability problem.

Natrium, a joint effort of GE-Hitachi and TerraPower supported by the DOE's Advanced Reactor Demonstration Program, will run a reactor at a steady state but interpose a tank of hot salt between the reactor and the power block. The design is meant for diurnal storage, making space for solar during the day but discharging when the sun goes down.

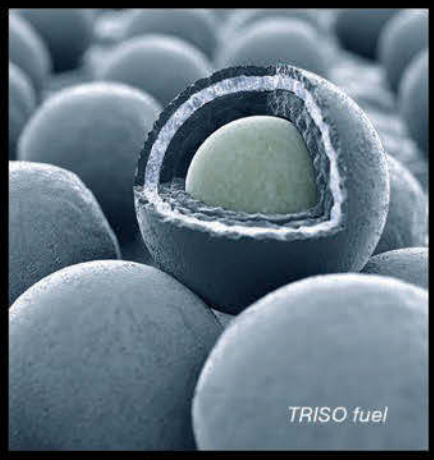
NuScale, which has a design that has been approved by the Nuclear Regulatory Commission, offers a cluster of small modular reactors that are similar to current reactors in that they are light water reactors. But they are much smaller and are designed differently from the plants that are running today and thus can vary their output on a scale of seconds, hours, or days. In its design, operators can send all the steam to bypass the turbine and go directly to the condenser. For longer-term variation, they can shut down a module.

The AP1000 units now approaching completion near Augusta, Ga., can load follow by using "gray rods," control rods that are partially transparent to neutrons that can be inserted to cut power production while allowing even consumption of the fuel.

But the latter two approaches, while simple, result in lost production and, as the INL study points out, reduce the number of megawatt-hours over which fixed plant costs can be spread.

Matt Wald is an independent energy writer and consultant. He is a former policy analyst at the Nuclear Energy Institute and for decades was the energy reporter at the New York Times.

Battelle Energy Alliance manages INL for the DOE's Office of Nuclear Energy. INL is the nation's center for nuclear energy research and development and also performs research in each of the DOE's strategic goal areas: energy, national security, science, and the environment. For more information, visit www.inl.gov.



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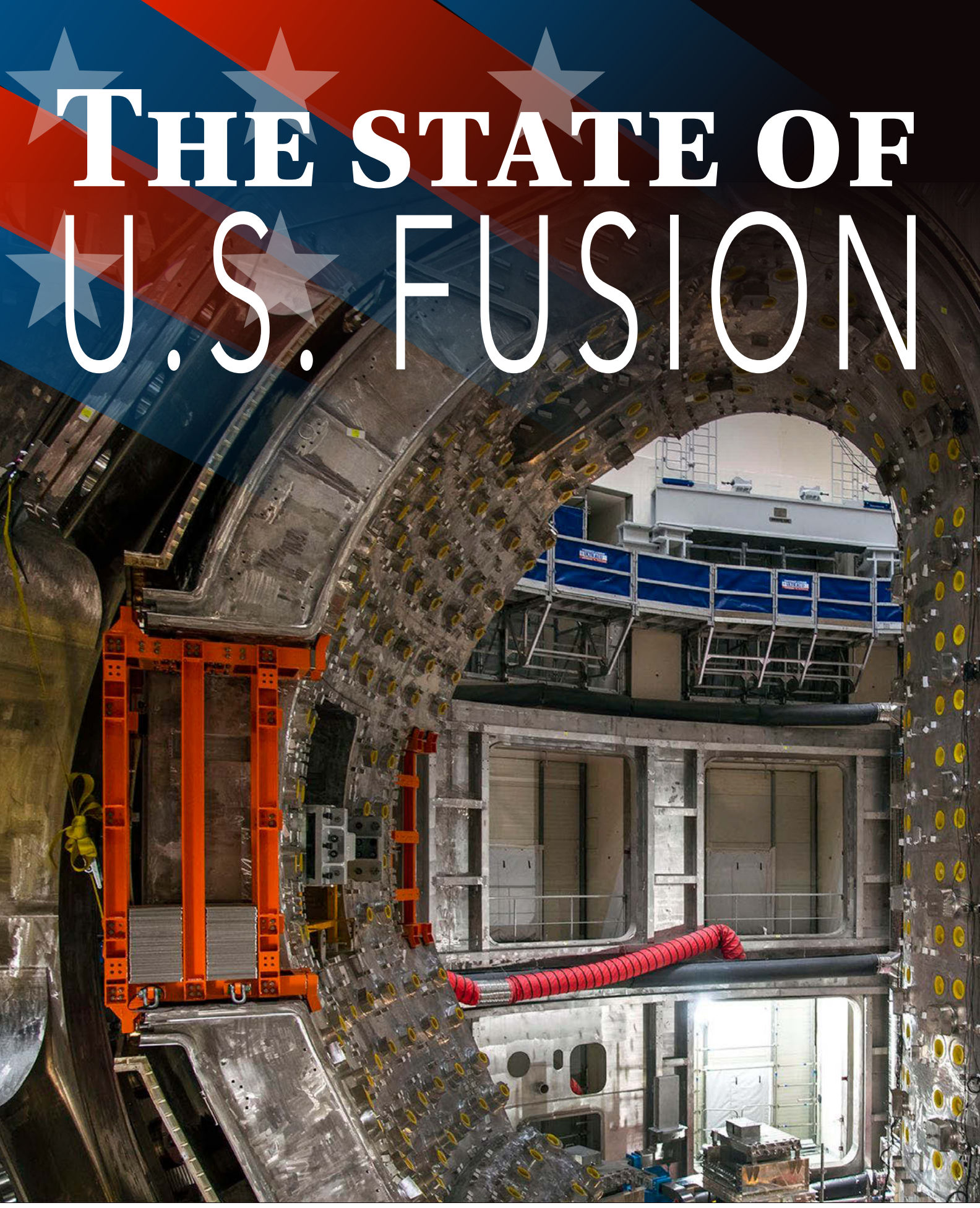

—AND WHY WE'RE TALKING ABOUT FUSION PILOT PLANTS

By Cami Collins

Delivery of electricity from fusion is considered by the National Academies of Engineering to be one of the grand challenges of the 21st century. The tremendous progress in fusion science and technology is underpinning efforts by nuclear experts and advocates to tackle many of the key challenges that must be addressed to construct a fusion pilot plant and make practical fusion possible.

As the globe reckons with the urgent need to reduce carbon emissions, the public and private sectors in the United States are working to expand carbon-free energy sources, including advanced fission and fusion. Across government, industries, and universities, there is strong support for an aggressive path to fusion energy that addresses the technical and scientific challenges and prepares fusion for the demands of delivering electricity to the grid.

Several key factors are contributing to this turning point in fusion: scientific discovery and applications of new technologies, consensus across the U.S. fusion community to focus on a path to commercialized fusion energy, substantial private investment in fusion industry, and new partnerships across public and private sectors.

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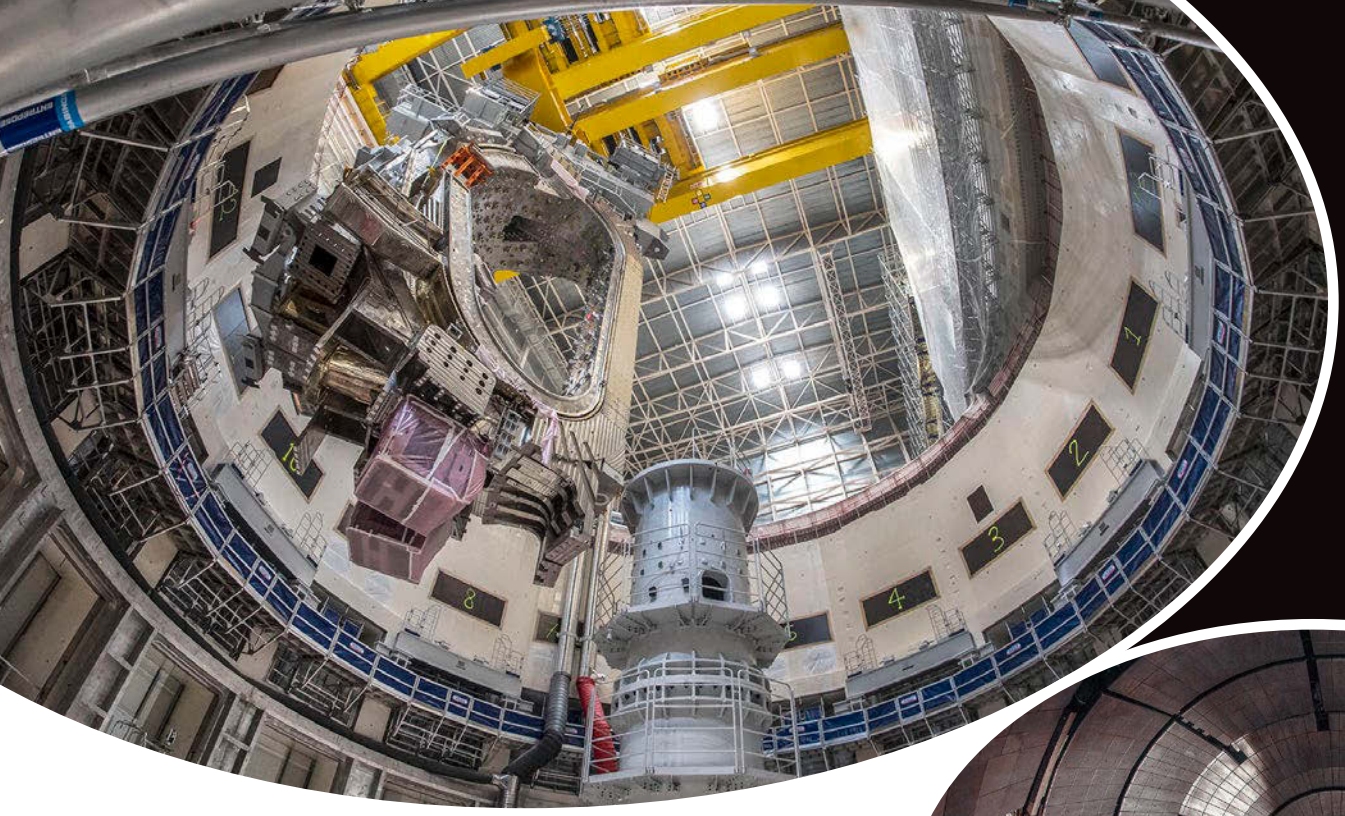
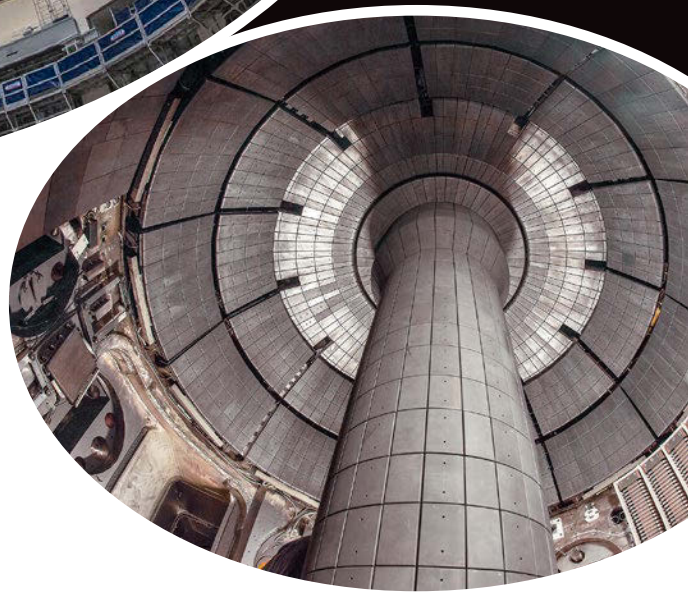
The first sector of the ITER vacuum vessel was placed in the assembly pit in May. Here, a technician positions targets on the surface of the component to be used in laser metrology. (Photo: ITER Organization)





Above: The first ITER vacuum vessel sector is lowered into the machine well. (Photo: ITER Organization)

Right: Inside the National Spherical Torus Experiment-Upgrade. (Photo: PPPL)

NEW DISCOVERIES AND TECHNOLOGIES

Significant advances have been made in fusion science and technology over the past two decades, many of which have been supported by public investment, through the Department of Energy national laboratories and user facilities and through university research supported by the DOE Office of Science. Magnetic confinement approaches to fusion, largely with donut-shaped tokamak machines, have been a prime focus of investment and research, resulting in deep experience and improved understanding. Other fusion confinement approaches have also made advances, typically through private investment.

The international ITER project, which receives support and participation from the U.S. government, is a multidecade effort that has yielded impacts across science and engineering. Tokamak assembly began in 2020, and the site and components are now more than 75 percent complete for first plasma operations. ITER is designed to produce a self-sustaining "burning plasma" that will operate for approximately 300 seconds and demonstrate 500 MW of fusion power. ITER has grown a fusion workforce and transformed the fusion supply chain, engaging industry, laboratories, and universities around the world. Every day, first-of-a-kind engineering achievements are accomplished at the project site and by ITER partners around the world, from the manufacture of superconducting magnets and leading-edge plasma heating technologies to the assembly of airplane-sized components with millimeter precision. Designing and fabricating qualified components for ITER provides the United States with practical fusion engineering and construction experience at reactor scale. In 2022, the U.S. fusion community prepared a draft report detailing many critical products and lessons to be learned through each upcoming ITER phase, spanning physics to engineering, diagnostics, and control of a large, nuclear, long-pulse facility. The report forms a plan to maximize the return of U.S.

The DIII-D National Fusion Facility tokamak interior. (Photo: General Atomics)

investment in ITER and ensure U.S. research on ITER strengthens and accelerates the development of a domestic fusion pilot plant.

Princeton Plasma Physics Laboratory has long been a leader in magnetic confinement fusion and plasma science. PPPL was home to the world record–setting Tokamak Fusion Test Reactor, which entered service in 1982 and was shut down in 1997. It was the first fusion device in the world to use 50/50 mixtures of deuterium and tritium as fuel and produced 10 MW of fusion power in 1997. Today, PPPL hosts the National Spherical Torus Experiment-Upgrade and is engaged in expanding its impact on fusion applications, including microelectronics and nanotechnology. The lab is also an active contributor to theoretical and advanced computing research focused on fusion.

The DIII-D National Fusion Facility, operated by General Atomics in San Diego, Calif., on behalf of the DOE, has been home to magnetic fusion research since the mid-1980s. Today, the facility has over 100 participating institutions and a research team of more than 600 people. The facility's D-shaped cross-section design has influenced fusion devices around the world, including KSTAR (Korea) and EAST (China). DIII-D is regarded as the most comprehensively diagnosed tokamak in the world, and its research and model validation has been especially important for ITER, both in early design periods and now in preparation for research operations. Key discoveries aided by DIII-D include understanding of plasma confinement during "H mode," or high-confinement operation; development of plasma control techniques; establishment of steady-state "advanced tokamak" plasma scenarios; and development of techniques for avoiding and mitigating plasma disruptions and undesirable transient plasma events called edge-localized modes.

Oak Ridge National Laboratory has over 50 years of fusion experience spanning many devices, national and global collaborations, and technologies. Today, ORNL is building the Materials Plasma Exposure eXperiment (MPEX) to support study of materials for fusion applications. The lab manages the U.S. hardware

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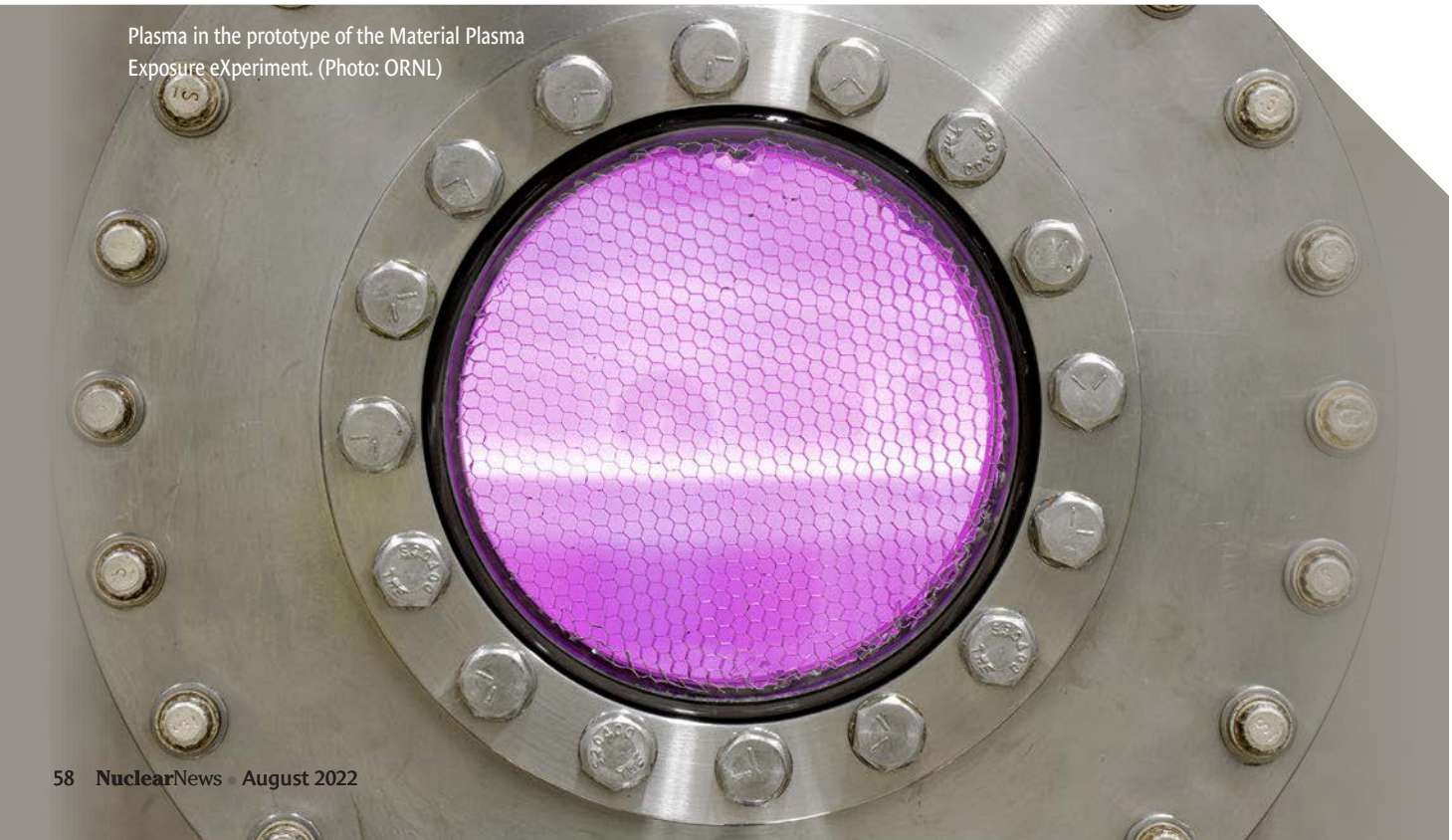
contributions for ITER while continuing to advance burning plasma science and fusion technology for public and private projects around the world. ORNL is also a leader in integrated modeling of fusion systems. Capabilities at ORNL include understanding both the plasma physics in the fusion core and the materials and engineering constraints of the surrounding components. Scientists and engineers are now applying this expertise toward developing reference designs for fusion pilot plants.

Lawrence Livermore, Los Alamos, and Sandia national laboratories also have a long history with fusion, tied to their national defense mission, and have played an important role in investigating fusion approaches other than magnetic plasma confinement. The National Ignition Facility at LLNL achieved a fusion milestone for inertial confinement fusion in August 2021, with a 25-fold increase in energy yield compared with the earlier record set in 2018. This facility uses high-energy lasers to put tiny hydrogen fuel pellets under extreme temperature and pressure. For a fraction of a second, the fusion reaction was driven primarily by the heat from other fusion reactions, approaching the threshold for ignition. For a practical inertial fusion energy system, higher energy yield and much greater driver efficiency and repetition rates would be required. Still, the achievement is a positive sign of the impact of expanded support for inertial confinement fusion research.

Universities are also critical contributors to fusion efforts, providing the central foundation to continuously develop the multidisciplinary workforce and bring essential talent, skills, and fresh perspectives to the fusion effort. Universities are training technical fusion experts; making discoveries; and building simulation tools, diagnostics, and technology innovations. Some institutions also host their own facilities or test stands for fusion development. The Massachusetts Institute of Technology, a longtime host of DOE-funded research and devices, is now partnering with the private fusion company Commonwealth Fusion Systems (CFS) to develop a compact, high-field fusion device that will take advantage of high-temperature superconducting (HTS)magnets. The University Fusion Association advocates for fusion research at universities. The need for increased coordination, opportunities, and pathways for engagement between university students, researchers, and professors with national laboratories and private industry has been identified in multiple fusion community reports.

Several factors have helped the national laboratories and universities accelerate their achievements in the



Plasma in the prototype of the Material Plasma Exposure eXperiment. (Photo: ORNL)

An HTS magnet designed and built by Commonwealth Fusion Systems and MIT's Plasma Science and Fusion Center. (Photo: Gretchen Ertl; CFS/MIT-PSFC, 2021)

past decade. High-performance computing has enabled high-fidelity modeling and simulation of fusion plasmas and devices. The richness of these simulations permits researchers to rapidly explore device and component design impacts, minimizing the number of test facilities that need to be built. Simulations and modeling are also key for preparing for high-confinement, high-power plasma operations that will be required in new devices, such as ITER, and ultimately for pilot plants and power plants.

Next-generation plasma diagnostics are also making a difference for fusion. Improved resolutions, techniques, and integration with high-performance computing enable measurements that were not even possible 10 years ago. U.S. experts contributed to diagnostics that helped measure a new fusion record in February 2022 at the Joint European Torus (JET), where researchers documented generation of 59 megajoules of sustained fusion energy, more than doubling the device's previous 1997 record. The high-power plasma phase lasted about 5 seconds and was hailed as the clearest demonstration to date of a viable path to carbon-free fusion energy.

In the future, the impacts of advanced manufacturing, integrated sensors, and artificial intelligence are expected to contribute to fusion development, including accelerated design and deployment of certified components and the optimization of operations.

In short, diverse contributors and sustained government investment in fusion and facilities have yielded new understandings of plasmas, new achievements in fusion performance, and new engineering capabilities relevant for preparing for practical fusion energy.

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A National Ignition Facility cryogenic target. (Photo: LLNL)

POISED TO ADVANCE FUSION ENERGY

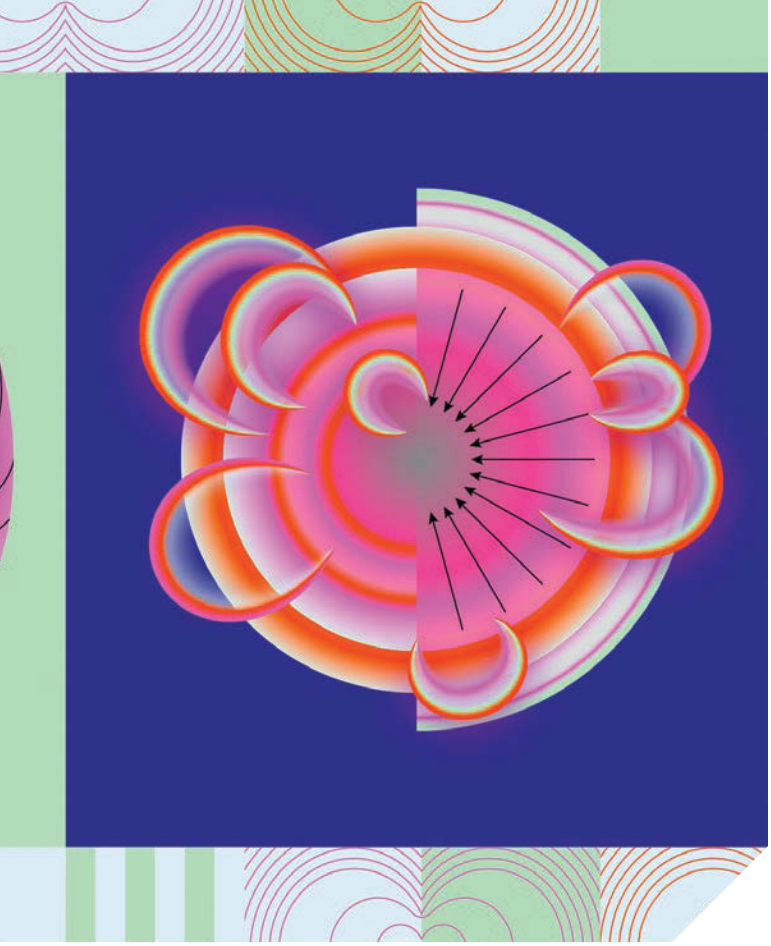
Members of the U.S. fusion research community, which spans the fields of plasma physics, nuclear engineering, and fusion technology, among others, are aligned with the pursuit of fusion for energy. There is an urgent need to address and solve specific challenges to achieve practical fusion, however.

In 2020, the final report of the American Physical Society Division of Plasma Physics (APS-DPP) community planning process, *A Community Plan for Fusion Energy and Discovery Plasma Sciences*, was made available. U.S. experts engaged in months of exchanges and discussions that culminated in this consensus report, which emphasized the equal importance of both fusion science and technology and discovery plasma science. The report conveys that preparation for a fusion pilot plant should be a prime organizing goal for fusion science and technology investments and outlined a prioritized set of strategic objectives needed to achieve this mission. This stands in contrast to past DOE-funded efforts, which have focused largely on plasma science.

The community plan specifically notes that research efforts should focus on further advancing the burning plasma physics basis necessary for a fusion pilot plant. In addition, further investment in fusion materials and technology is recommended. It urges innovation to drive the achievement of economically viable fusion—whether that be in transformative science, technologies, or coordination and integration of impacts from other fields.

Following the release of the community consensus report, the DOE Fusion Energy Sciences Advisory Committee issued a long-range planning report, *Powering the Future: Fusion & Plasmas*, in 2020. The executive summary opens with this statement: "Now is the time to move aggressively toward the deployment of fusion energy, which could substantially power modern society while mitigating climate change." The report articulates how investment in fusion and plasma research is changing the world—in energy and other sectors—and that unique international and public-private partnerships are situating the United States to accelerate the development of fusion energy. In concert with the community plan, this report notes that there are areas of fusion technology development that require serious attention now to address critical gaps between present fusion capabilities and the requirements for a pilot plant and, ultimately, fusion power plants.

In 2020, the DOE asked the National Academies of Sciences, Engineering, and Medicine to identify key goals and innovations needed to support the



(Image: Ana Kova for U.S. Fusion Outreach)

development of a U.S. fusion pilot plant. The resulting 2021 report, *Bringing Fusion to the U.S. Grid*, presents a strategic plan for the design, construction, and operation of a fusion pilot plant. The report contributors conclude that the DOE should move forward now to foster the creation of national teams, including public-private partnerships, that will develop conceptual pilot plant designs and technology roadmaps, leading to an engineering design of a pilot plant that will ultimately bring fusion to commercial viability. The contributors note that a time frame of 2035–2040 for a fusion pilot plant, dictated by the goal of making an impact on the transition to a low-carbon-emission electrical system by 2050, requires immediate and urgent investments by both the DOE and private industry in order to solve the remaining technical and scientific issues and design, construct, and commission a pilot plant.

One of the first achievements to emerge from the APS-DPP community plan was the November 2021 launch of a website, usfusionenergy.org, designed and hosted by members of the U.S. Fusion Outreach Team. The website is a centralized resource for all audiences, featuring jobs and internship opportunities, a "fusioneer" portal with resources for anyone working to get fusion energy on the grid, K–12 educational materials and events, curated news stories, and media resources.

URGENT CHALLENGES AHEAD

Despite all the current advances, there remain significant scientific and technical challenges to resolve and economic risks to manage. None of these are trivial or guaranteed to yield a successful outcome; however, much is possible with the continued shared focus, investment, and determined effort of the fusion community and government sector.

Fusion's appeal as an energy source is rooted in nuclear science: Fusion reactions release even more energy per unit mass than fission reactions, and fusion reactors use fuel that is potentially abundant. Plus, the by-products of a deuterium-tritium reaction, helium plus an energetic neutron, lessen some of the challenges posed by fission products, particularly those of waste disposal.

Three main technical challenges must be resolved for fusion to be realized as a viable energy source.

First, practical fusion demands the production and control of a sustained fusion power source. For competitive commercial fusion energy, the plasma must be mostly self-heated rather than heated by external sources. In typical fusion designs, external heating is necessary to initiate fusion, but a self-heated burning plasma is achievable when enough fusion reactions are maintained over time with enough energy and enough confinement. ITER is specifically designed to achieve a self-heated, 500-MW plasma for 300 seconds with deuterium-tritium fuel, though this has yet to be fully realized. The readiness to deliver a sustained power source that can be rapidly scaled and commercialized to deliver reliable, economically viable, electricity-producing power still requires substantial development.

A second significant technical challenge is the development of materials appropriate for fusion reactor components. At this point, qualified materials that can withstand sustained fusion conditions over the lifetime of a power plant are not yet available. Developing materials, technology, and design solutions that ensure sufficient lifetimes of fusion reactor components applies to multiple fusion concepts. Moreover, materials will

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likely set the timescale and economics for viable fusion power plants. Fusion material needs are even more extreme than in current fission reactors. In a fusion reactor, components immediately surrounding the burning plasma will receive heat and particle flux from the plasma, as well as neutron heating and degradation from deuterium-tritium fusion reactions. Some materials can absorb fusion fuel, and materials breakdown could pollute or even extinguish the plasma. Materials properties and evolution under operation also impact heat extraction for electricity conversion. These materials must also protect ex-vessel components and superconducting magnets from neutron fluence. Furthermore, materials performance has implications for safety and licensing. Activities are currently underway to plan and develop testing environments for fusion materials that will accurately simulate fusion power plant conditions and aid in the assessment of novel materials.

A third major science and technology challenge is related to the fusion fuel cycle: the need to develop new technologies to capture fusion power efficiently. Even more fundamentally, tritium fuel will need to be produced from components inside a fusion reactor if the fuel cycle is to be closed and sustainable. It is assumed that deuterium-tritium fusion reactions will fuel the first generation of fusion pilot plants and power plants, because the reaction is "easier" to achieve. Though it is a limited resource, tritium can be produced when neutrons react with lithium. However, the production of tritium depends on specific fission reactors until fusion reactors can breed their own tritium. At present, there is enough tritium available for research and development activities, but the short half-life of tritium, combined with anticipated supply chain issues, adds pressure to that supply. For future pilot and power plants, new sources of tritium will be necessary. The United States is in an early stage of establishing the research and engineering activities necessary to meet the technology needs for breeding tritium and handling fusion power in the most efficient manner.

Outside of these technical challenges, fusion must also prepare for the demands of delivering baseload electricity in a safe, reliable, predictable manner that intersects productively with utility portfolios. As outlined in *Bringing Fusion to the U.S. Grid*, it is essential that preparations for a fusion pilot plant engage current utilities and energy stakeholders and incorporate lessons learned from the current nuclear industry.

NEW PARTNERSHIPS AND INVESTMENTS IN FUSION

The Biden administration recently announced a decadal vision for accelerating fusion energy and established a DOE fusion coordinator to work with the research and industrial sectors. This approach follows the recommendations of *Bringing Fusion to the U.S. Grid*: The "DOE should move forward now to foster the creation of national teams, including public-private partnerships, that will develop conceptual pilot plant designs and technology roadmaps that will lead to an engineering design of a pilot plant that will bring fusion to commercial viability." After a March 2022 White House summit, the DOE organized a multiday workshop in June about fusion energy development via public-private partnerships and a new milestone-based funding program. The topics explored ranged from technical challenges to practical considerations for effective cross-sector partnerships.

More than 25 private fusion companies have been established in the United States, and it is estimated that more than $4 billion has been invested in the U.S. fusion industry over the past decade. In September 2021, CFS demonstrated the performance of a large HTS magnet at 20 tesla. In 2022, Tokamak Energy achieved >100 million degree Celsius core ion temperatures in their spherical tokamak, ST40. This investment shows a business appreciation for energy innovation and edge energy opportunities to address global needs for carbon-free electricity. Industry groups such as the Fusion Industry Association continue to grow and advocate for the expansion of government funding for private fusion activities. Some companies are closely associated with government-funded research entities. Many private companies are exploring new confinement concepts for containing fusion reactions; some are proposing using novel fuels for fusion. Others are focused on near-term applications for fusion outside of electricity production.

Meanwhile, the DOE continues to support other avenues for private fusion engagement with public sector expertise. The ARPA-E program supports development of high-potential, high-impact technologies through short-term projects, some of which include high-power gyrotron, radio-frequency heating, neutronics modeling, and HTS magnet technology development for

fusion applications. Project teams can include both publicly and privately funded institutions. The DOE Innovation Network for Fusion Energy (INFUSE) program provides the fusion industry with opportunities to access the technical support available at DOE laboratories and universities that is necessary to move new or advanced fusion technologies forward. Since 2019, INFUSE has supported 47 collaborations with industry partners, including projects with CFS, Energy Driven Technologies, General Fusion, HelicitySpace, Magneto Inertial Fusion Technologies, Renaissance Americas, TAE Technologies, and Tokamak Energy.

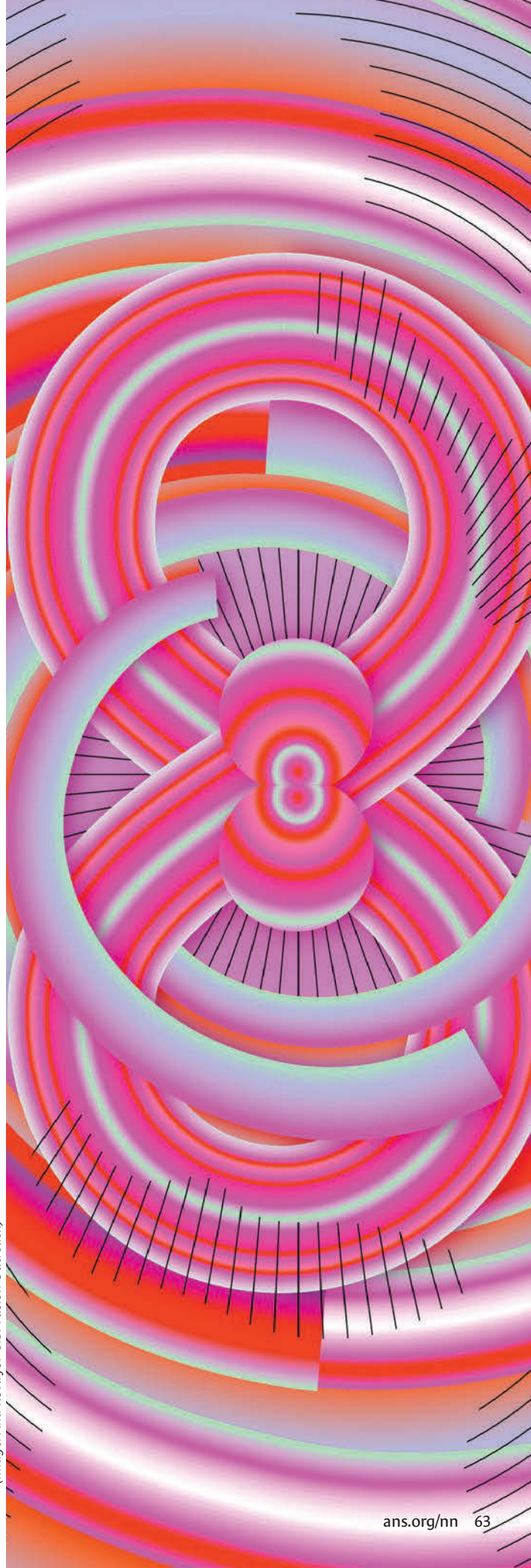
WHAT'S NEXT?

As the private, public, and government sectors work toward the common goal of a U.S. fusion pilot plant, an essential step to practical fusion electricity, experts agree that much remains to be done on the science and engineering side to realize the technologies that will bring this goal to fruition.

To clear the path to commercialization, rapid expansion is necessary across multiple disciplines and entities to resolve low technology readiness level issues. Open communication, collaboration, and coordination between public and private stakeholders to disseminate knowledge, technology, and experience will accelerate progress. Tactical research and development is needed to maximize the probability of credible power plant designs reaching commercial viability. Across sectors, the community must draw on all resources, including critical lessons learned and data from ITER, the nuclear industry, private industry, and other domestic and international facilities and industries. Above all, U.S. fusion goals require rapid expansion of a diverse workforce with expertise in fields from physics to nuclear science to materials science, as well as all types of engineering and computer science, and even economics and public policy. Though we may not be able to predict when fusion will join fission as a crucial component of the U.S. carbon-free energy portfolio, our expert opinion from the field is that this coming decade will be a pivotal one for the future of fusion.

Cami Collins (collinscs@ornl.gov) is an R&D scientist and the advanced tokamak group leader in the Fusion Energy Division at ORNL. She has served on multiple community planning program committees, in APS-DPP, and in fusion outreach, with a special focus on recruitment and retention of women in fusion energy careers.

To keep up with current fusion news, resources, and job opportunities, visit usfusionenergy.org.



(Image: Ana Kova for U.S. Fusion Outreach)

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Power Plant Maps
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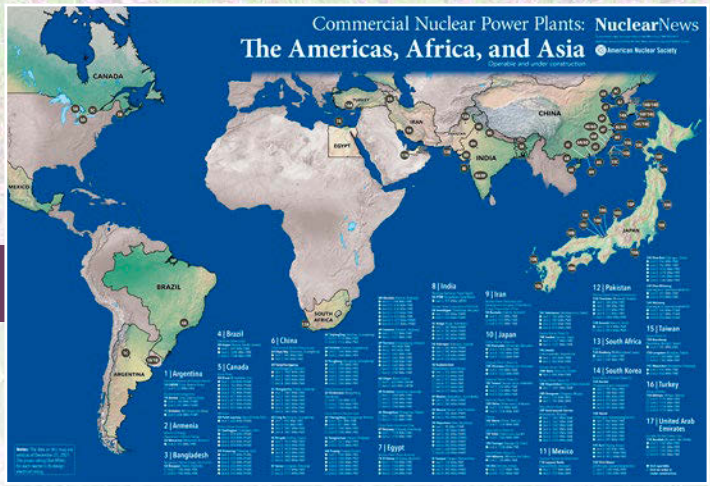


Choose from three updated and newly designed wall maps that together show the location of every commercial power reactor in the world that is operable, under construction, or ordered as of Dec. 31, 2021.

Each map includes a table that lists the generating capacity, design type, date of commercial operation (actual or expected), and reactor supplier.

- **United States of America**
- **Europe and Russia**
- **The Americas, Africa, and Asia**

Purchase individual maps, or save by ordering a two or three-map combo.

Order today at ans.org/maps

ANS members save 10%!

ANS®

Dimensions are 39.25” X 26.75”

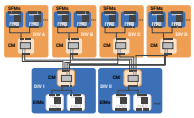
28th Annual Vendor/Contractor Profile Section

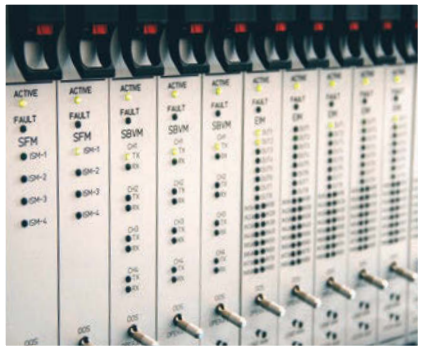

The Highly Integrated Protection System (HIPS) platform is a game changer
Today's nuclear power plant operators want safety-related systems that work for multiple decades without major upgrades. Previous generation digital I&C systems required frequent firmware updates and proved difficult to manage under current cybersecurity and regulatory constraints.
The SER-approved HIPS FPGA platform was designed with you in mind.
HIPS performs with robust, analog-like reliability while providing essential diagnostics to enable plants to reduce O&M costs.
Paragon
The nuclear industry's most trusted supplier
865-888-6853 | www.ParagonES.com

HIPS: Forged on the Leading Edge of Advanced Reactor Ingenuity

RPS Architecture

The scalable HIPS platform has complete architecture flexibility. It can be configured as a single channel or up to a full Reactor Protection System of four separation groups which votes into two divisions complete with physical and electrical isolation.





Paragon's HIPS platform

Class-1E SER Approval

The HIPS platform topical report TR-1015-18653-P, Revision 0, "Design of the Highly Integrated Protection System [HIPS] Platform" was submitted in 2015 in partnership with NuScale. Rev. 1 was submitted in 2016 with NRC SER approval granted in 2017.

Model-Based Design

Model-Based Design provides a significant increase in the quality of the final product and a reduction of project execution costs.

It's an all-in-one environment to meet the rigorous development requirements for safety critical systems in a significantly reduced development time by integrating both the system's functional behavior and the detailed description in one project model.

HIPS Model-Based Design automates error prone and time-consuming tasks, reducing the development time associated with code and document generation, test execution, and model checks.

Additionally, simulation of the system behavior provides the ability to examine its interaction with individual components to detect errors in requirements and design early in the development lifecycle before testing on expensive hardware.

Software Common Cause Failures Mitigated by Internal Diversity

The diversity in our FPGA equipment, circuit designs, and software tools are the fundamental methods for mitigating the potential for digital Common Cause Failures (CCFs) in the HIPS platform.

The platform design uses two diverse FPGA technologies to achieve equipment diversity: one is a one-time programmable (OTP) or flash-based FPGA, with the other a static random-access memory (SRAM) based FPGA.

The overall HIPS diversity approach aligns with NRC BTP 7-19 and provides additional benefits by simplifying the holistic I&C facility design, since a separate diverse actuation system is not required to mitigate digital CCFs.

The diversity approach also provides analytical and regulatory review benefits, since additional 'best estimate' consequence analysis is not required. This ensures a more efficient regulatory turnaround and quicker system build for a higher level of confidence in meeting your project deadlines.

Why is field programmable gate array (FPGA) technology the right choice for your nuclear power plant?

SIMILAR TO DIGITAL	... BUT BETTER
High reliability from comprehensive diagnostics & self-testing	✓ Deterministic—**costs less** to qualify
Flexible components (reconfigurable, reusable, portable logic)	✓ **Reduced complexity** means greater regulatory certainty
Fault tolerant	✓ **No executable software**
Software enhanced application development	✓ **Inherently more cyber-secure**
Configurable communications	✓ **Resilient to component obsolescence**
	✓ **Isolation of independent functions** (safety/non-safety) within the same system
	✓ **Quicker processing time** due to parallel execution of independent functions
	✓ Intuitive bypass and testability

To learn more about the HIPS Platform, visit www.ParagonES.com/HIPS

AECON-WACHS

MECHANICAL
& ELECTRICAL
PROJECTS

FABRICATION &
MODULARIZATION

QUALITY
MANAGEMENT
PROGRAM

Aecon-Wachs, in collaboration with our parent company Aecon Nuclear, is a total solutions provider.

We provide a full spectrum
of Engineering, Procurement
& Construction (EPC), maintenance and
manufacturing services specifically tailored to meet
the demanding requirements of the nuclear power industry.

Jackson, SC | 803.508.7308 | aecon-wachs.com

Aecon-Wachs has created your One-Stop-Shop for Mechanical Construction

Whether you are designing a piping system and need to eliminate welds through pipe bending, you are replacing feedwater heaters, critical valves and pumps, or need contract supervision and labor for your outage or capital project, Aecon-Wachs has a solution to meet your demands.

Nuclear clients appreciate our proven Safety Program, Quality Program, Weld Program and flexibility to utilize our programs and procedures OR the clients'.

Audited by NUPIC members and NIAC members, our 10CFR50, Appendix B, ASME & ISO 9001 Programs offer you access to elite Field Service and Shop Fabrication services.

NO LOST TIME INJURIES
OVER 4.5 MILLION MAN HOURS
Safe, because we all care.

ASME U ASME S R NB

EXPERIENCE MODIFICATION RATE (EMR)

2019 - 0.57	2020 - 0.63	2021 - 0.71

CORE COMPETENCIES

- Large Component Replacements
- Design, Fabricate, Install
- Turnkey Projects
- Specialty Welding & Machining
- Heat Treating, Coatings
- Lifting/Rigging
- Metrology
- Staffing

NUCLEAR MARKETS

- New Construction
- Operating Plants
- Decommissioning
- Department of Energy
- Department of Defense
- Medicine

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.

framatome

Advanced Fuel Management: Raising the standard for nuclear fuel

Today's light water reactor fleet is critical in helping meet climate initiatives and provide a constant source of low-carbon energy. In a competitive energy market, Framatome has committed to identifying and developing solutions to improve both the safety and economics for nuclear plant operators.

Framatome launched its Advanced Fuel Management (AFM) program, a subset of its PROtect enhanced accident tolerant fuel (EATF) program, focused on bringing a substantial improvement to fuel performance. The AFM program is focused on combining enrichment and burnup improvements to augment sustainability of the commercial nuclear reactor fleet. These two improvements to our most advanced nuclear fuel designs, taken together, improve fuel utilization, while increasing cycle lengths and reducing down time, creating significant value for plant operators.

What is Advanced Fuel Management?

AFM is a globally integrated program designed to deliver fuel with higher enrichment and burnup limits. Enriching uranium oxide (UO_2) above the traditional 5 wt% thresholds combined with Framatome's latest technology allow nuclear plant operators to maximize energy production. The increases in enrichment and burnup open the door to improved economic performance by extracting more cycle energy from a reactor core and reducing Operations & Maintenance (O&M) costs.

This program is built on more than 60 years of nuclear fuel experience and encompasses all aspects of the nuclear fuel cycle including enrichment services, regulatory licensing and fuel fabrication infrastructure.

What are the benefits of this advanced fuel design?

As light water reactors begin operating past their original 40-year design life they continue to face increasing pressure to improve their plant's economic outlook. Framatome is modifying the traditional fuel pellet with enrichments so plants will have more flexibility for efficient core designs and longer operating cycles.

By extending traditional 18-month fuel cycles in pressurized water reactor (PWR) designs to 24-month cycles, operators can reduce outages and downtime. Over a six-year period, a plant operator can eliminate one outage, saving nearly $30 million. Fewer outages also mean increased safety as the fuel handling and dry cask storage demands are reduced.

Industry-wide effort

To disrupt the traditional nuclear fuel market, Framatome is collaborating with the entire nuclear energy industry to bring this new technology to market. This effort requires synergy between utilities, enrichment services, regulatory and licensing governance and Framatome.

Project support

The project has also garnered support from the U.S. Department of Energy (DOE) as the EATF and AFM programs can sustain the existing reactor fleet to help meet carbon reduction goals. Framatome and the DOE signed a $150 million cooperative agreement in 2021 to support the industrialization of higher enriched fuel.

Where are we today?

The multi-year effort achieved some major milestones in the past 18 months. Last year, the U.S. Nuclear Regulatory Commission (NRC) accepted for review a topical report on the application of Framatome's advanced codes and methods to operating conditions with uranium enrichments above 5 wt%. This submittal is a critical step toward introducing advanced products with increased enrichments and burnups.

Earlier this year, Framatome achieved another regulatory milestone when the NRC approved Framatome to transport fuel up to 8 wt%, ensuring once the fuel is manufactured it can be delivered to the customer.

Path to commercialization

The incremental steps and project milestones that are required to bring this technology to market will take place over the next four years with a commitment to be reload ready in 2026. We recognize the challenges that await us, however when it comes to providing safer, more efficient nuclear fuel and fuel-related products to our customers, our commitment is unwavering.

YouTube

www.framatome.com

Outsourced Services

Our services are customized to meet your complex requirements across a wide spectrum of specialized and technical capabilities including:

- Advanced Nondestructive Testing and Quality Control Inspection
- NDE capabilities include 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

Workforce Solutions

We design and deliver workforce solutions to meet your unique requirements for contract and permanent staff, both single placements and high-volume engagements. Our dedicated “nuke squad” team of operations staff and recruiters, coupled with advanced technologies, quickly deliver the talent required 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 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

Let System One assist you in your project requirements. Learn more at systemone.com or contact us at nuclear@systemone.com

Scan to Learn More

Sargent & Lundy

A Proven Leader in Nuclear Digital Upgrades

For over 65 years, Sargent & Lundy has been actively involved in design and retrofit activities for nuclear units.

We're the preeminent supplier of digital I&C services through the full digital upgrade project lifecycle and have successfully completed over 300 digital upgrade projects over the past 10 years. We understand the unique complexities of these projects and the variety of challenges our clients face in retrofit design, planning, equipment compatibility, and implementation. By leveraging our breadth of digital experience and lessons learned, we're consistently able to help clients successfully navigate these project challenges and drive projects to completion.

INITIAL SCOPING PHASE
- Feasibility analysis
- Alternative analysis
- Stakeholder needs
- Modernization strategy
- Training

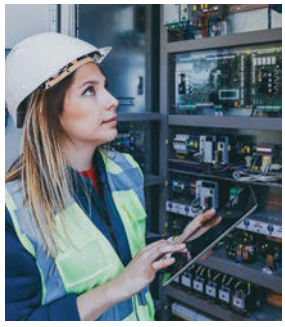
DESIGN PHASE
- Design engineering
- Engineering change packages
- Calculations
- Drawings

PLANNING PHASE
- System integration
- Iterative schedule review
- Work orders
- Test procedures

IMPLEMENTATION PHASE
- Staging area design
- Testing
- Post-turnover tuning and monitoring

Sargent & Lundy is working on a rapidly growing set of consulting, technical design, and hands-on programming/system integration projects using our newly constructed I&C labs. These projects include main control room modernizations and control system upgrades that support the long-term sustainability of the U.S. nuclear fleet. When installed, our designs will enable our clients to reduce O&M costs and safely operate their nuclear assets to generate thousands of megawatts of carbon-free electricity.

DIGITAL I&C CONSULTING SERVICES
- Strategic digital licensing
- Requirements specifications
- Cost benefit analyses
- Digital platform selection
- Independent third-party reviews
- Human factors engineering
- Cyber security
- Training



DIGITAL I&C IMPLEMENTATION SERVICES
- Risk elimination
- Contingency Planning
- Configuration management
- Value engineering
- Quality planning
- Installation scripting
- Development of utility subject matter experts

Get to know excellence.
Get to know Sargent & Lundy.

sargentlundy.com

PETERSEN

A **PRECINMAC** Company

New Look

Same focus on quality & delivery.

Same Petersen, just better!

We are excited to show you our new logo and brand colors, but Petersen is still the reliable manufacturing partner you have always known, we've just gotten better! From NQA-1 fabrication to aerospace quality precision machining, there is no job too big or too small for Petersen to handle.

What can we build for you?

About Precinmac

Precinmac is a leading global diversified manufacturer of high-tolerance precision machined components and fabricated products for high-requirement industries.

With eight locations in the United States and Canada, we are an ideal single-source partner for medium - high complexity projects that rely on close tolerance fabrication and precision machining.

peterseninc.com

PETERSEN

A **PRECINMAC** Company

Petersen is a leader in advanced manufacturing - fabricating and machining specialized and high-grade containers/casks, gloveboxes, melters, reactor services, and process equipment for the nuclear industry.

Many Department of Energy projects have relied on Petersen's high-quality NQA-1 expertise, including the Hanford Waste Treatment Plant, Savannah River Site, WIPP, LANL and more. Additionally, many clean-up, demolition, and disposal projects have contracted with Petersen to produce process equipment to support the safety and proper storage of radioactive material.

NUCLEAR GLOVEBOXES

Providing only the highest grade of nuclear glovebox equipment, our gloveboxes have been used in high-profile projects such as the Department of Energy's MOX project at the Savannah River Site, the Waste Treatment Plant – River Protection Project Vitrification facility at the Hanford, Washington State site and LANL CMRR Project. Petersen glovebox enclosures provide a safe and controlled processing and handling system for nuclear and radioactive products.

Our gloveboxes are used in systems like:

- UPF at Y12
- Research and development
- TRU waste processing, characterization and packaging
- Radioactive material handling
- Tritium capture and processing

CASKS

Petersen is an industry leader in the manufacturing of spent fuel containers and casks, including lead-lined casks. Spent fuel refers to nuclear fuel elements that have been used at commercial nuclear reactors but are no longer capable of economically sustaining a nuclear reaction.

This spent nuclear fuel then needs to be properly stored and properly disposed of. Companies have relied on us to produce high quality containment products for safe, reliable storage of spent fuel. Our in-house proven quality systems and experience ensure that your products are being manufactured to the highest standards in the industry.

REACTOR SERVICES

With years of experience in commercial nuclear reactor services, Petersen is equipped to safely supply products that handle radioactive treatment needs. We continue to provide ongoing safe solutions to high-profile projects with the Department of Energy, utility, and nuclear related customers. Our planning and expertise ensure timely service, successful project implementation and execution for our clients.

PROCESS EQUIPMENT

Petersen offers state-of-the-art facilities specializing in the manufacturing of process equipment, transportation equipment, special handling and monitoring equipment, as well as spent fuel containment containers and casks of all sizes. We also provide custom manufactured equipment for decommissioning projects.

We continue to manufacture process equipment that is used to develop and test new processes to meet the demands of nuclear facilities and technology advancements.

Our safe, customer friendly environment and experience allows the Petersen team the ability to interface and work alongside our customers' team on a daily basis an we welcome on-site support.

Certifications

- ASME U, U2, S, R
- NQA-1
- ISO9001:2015
- NRC Subpart H of 10CFR71
- AS9100 Rev D
- AISC

Westinghouse

Westinghouse Parts Business (WPB) Resistance Temperature Detector (RTD)

Designed to meet the harsh requirements surrounding a nuclear reactor, specialized Reactor Temperature Detectors (RTDs) are utilized in containment primary loops to monitor and provide critical primary hot and cold leg coolant temperature input critical to safe plant operations. Such a crucial component requires exceptional performance to ensure accurate and timely readings.

The Westinghouse Parts Business (WPB) is introducing the next generation RTDs. This newly designed RTD is more robust than previous designs, solving a performance issue of premature failures due to high frequency vibration and also addresses an obsolescence issue since the previous design was no longer available for purchase. This RTD replacement is designed to be installed directly into existing thermowells, minimizing outage schedule impact.

Benefits of RTD Supply with Westinghouse:

- Part Availability: Westinghouse will ensure that the required source of supply is maintained for maintenance and "end of qualified life" replacement requirements.
- Ease of Replacement: Like-for-like replacement that can be installed into existing thermowells, minimizing outage schedule impact
- Performance: Mitigates premature failure due to system vibration parameters
- Part Quality: Westinghouse has been the industry leader in qualified RTDs with extensive expertise in technical and plant installation support.

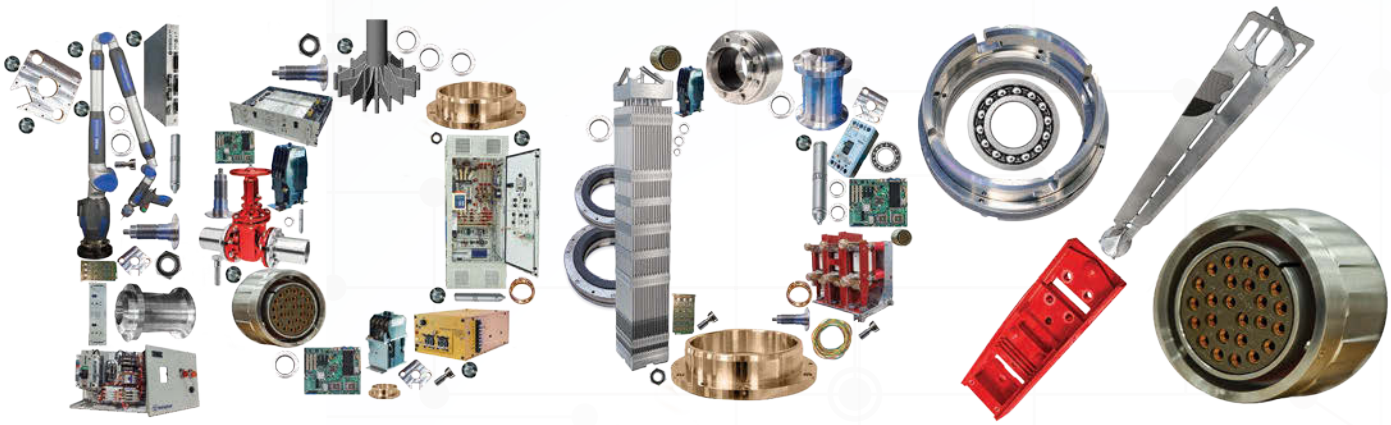
Narrow Range Resistance Temperature Detector

The newly designed Westinghouse Narrow Range RTD was developed to withstand high vibrations to mitigate premature failures experienced in the industry.

Wide Range Temperature Detector

The Westinghouse wide range response RTD is designed to be installed in existing thermowells and will maintain the required detection of temperature changes in the hot and cold legs of the reactor coolant loops of PWRs.

Westinghouse is excited to be working with the industry on solving this issue.
For more information on Westinghouse Parts Solutions visit,
www.info.westinghousenuclear.com/westinghouse-parts-business.



Westinghouse technology is fundamental to nearly **50% of the world's nuclear reactors**. Now, that same trusted expertise is delivering the services and parts to meet the needs of **100% of the nuclear plants across the globe**.

From small to large.

Whether your project involves new construction or existing equipment, for a nuclear plant or a government facility, Westinghouse provides high-quality, nuclear-qualified solutions and products that meet the original design and qualification of your plant.

Global to local.

Our cost-effective, high-quality, nuclear-grade replacement parts provide global operators of various reactor designs solutions for electrical, mechanical, and instrumentation and control systems.

From Westinghouse's proprietary innovations to designs around the world.

Westinghouse has a rigorous commercial-grade dedication process and a robust quality assurance program for detecting and monitoring counterfeit, fraudulent and suspect replacement parts and components. And our industry-leading experts are available 24/7 to support your plant needs.

To learn how we're **shaping tomorrow's energy**, visit: **www.westinghousenuclear.com/parts**

Westinghouse

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GDBarri
& Associates, Inc.

Come visit us at the UWC-Booth 206

Barri is a MWBE staff augmentation firm with over 30 years of experience. An industry leader, we specialize in the power industry, where we provide highly skilled labor solutions for a full range of disciplines to meet our client's short and long term project and supplemental needs.

NUCLEAR
FOSSIL
GAS
TURBINE
ALTERNATIVE FUELS

QUALITY & EXCELLENCE

Barri actively recruits and places professional, technical and union craft personnel for operations, maintenance, capital improvement, and other projects. Our experience over the last three decades has prepared us to be an effective partner to our clients, and our knowledge of safety, labor agreements, employment rules and regulations, together with strong labor analysis and customizable reporting capabilities will help you achieve your business goals.

certified WBENC WOMEN'S BUSINESS ENTERPRISE

NMSDC 50TH ANNIVERSARY CERTIFIED MBE 2022

For more information, contact Alex M. Dorsey, Pres./CEO or Jeff A. Wenger, CFO at
(623) 773-0410
www.gdbarri.com

Holtec International is a privately held technology company with operation centers in Florida, New Jersey, Ohio and Pennsylvania in the U.S., and globally in Brazil, Canada, India, Japan, Mexico, South Africa, Spain, U.K. and Ukraine. Since the 1980s, Holtec has played a preeminent role in the energy industry by developing and implementing innovative solutions to overcome technical challenges faced by its clients around the world. Pioneering the technology to expand the nuclear fuel storage capacity in the wet storage pools, Holtec has increased the storage capacity on average by over 50% at over 110 reactor units worldwide. Over 130 nuclear units worldwide rely on Holtec's technology for spent nuclear fuel storage and transportation; 70 of these are located in the U.S. Highlights of Holtec's core business focus also includes the safe and efficient decommissioning of shuttered nuclear plants; the current fleet includes Indian Point, Pilgrim and Oyster Creek. Holtec's decommissioning model includes the assumption of the entire plant including the spent nuclear fuel. Holtec's approach to decommissioning is to begin and complete the physical work of decontamination and dismantlement decades sooner than if the current nuclear plant owner retains ownership of the plant. HI-STORE, the world's first below-ground Consolidated Interim Storage Facility, is currently undergoing licensing for deployment in New Mexico. Holtec's SMR-160, a 160-Megawatt small modular reactor, will provide safe, secure, dependable, affordable and carbon-free power even in the world's most arid regions. As a major supplier of special-purpose pressure vessels and critical-service heat exchange equipment, Holtec provides air-cooled condensers, steam generators, feedwater heaters, and water-cooled condensers. As a fully integrated supplier, Holtec possesses in-house capabilities to design, engineer, analyze, license, fabricate and construct these technologies.

Key Facts:

- Holtec is a vertically-integrated supplier that possesses in-house capabilities to design, engineer, analyze, license, fabricate and perform on-site construction.
- Holtec has a global presence with operation centers located in 10 countries around the world.
- Holtec's four manufacturing facilities (three in the U.S. and one in India) cover over 1 million square feet of manufacturing floor space.
- Holtec Manufacturing Division is one of America's largest exporters of capital equipment for the nuclear industry. It is also among the largest manufacturers of ASME Code components.
- Since its founding in 1986, Holtec has maintained a solid record of consistent profitability. Today, Holtec has a bonding capacity of $500 million and an excellent credit rating.
- Holtec has been granted over 150 patents in areas of equipment design, fabrication processes and materials.
- Holtec's engineers helped develop the modern ASME Code, HEI and TEMA standards for design and construction parameters for shell and tube heat exchangers, water-cooled and air-cooled condensers.

thermoscientific

The best imager for many applications.....
The only imager for some!

Thermo Scientific – CIDTEC is a supplier of radiation hardened, machine vision, and scientific cameras based on the proprietary Charge Injection Device (CID) technology for use in the most demanding imaging applications.

MegaRAD series

- The MegaRAD series of cameras are capable of operating in high dose radiation environments such as nuclear reactors, fuel inspection, hot cell monitoring, remediation, surveillance, and X-ray imaging applications. Most importantly, this capability can now be provided in either Monochrome or Color version cameras, with remote head cable lengths up to 150-meters.
- The radiation hard PPP (Preamplifier Per Pixel) CID imager technology allow exceptional signal to noise with sensitivity never before available with radiation hardened cameras.
- These cameras have been tested and proven in high levels of gamma radiation, and since readout is within the pixel, loss due to SETI's (single event transfer inefficiencies) is minimized.
- 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.

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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

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Email: sales.cidtec@thermofisher.com

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

ThermoFisher SCIENTIFIC

NAC International Poised to Address New Challenges

As the nuclear energy industry supports zero-carbon goals and advanced reactors move towards deployment, NAC is ready with solutions that build on our 50+ year history of providing transportation, packaging, storage, and fuel cycle consulting and information.

Unrivaled Transport Capabilities
With 30+ years transporting spent fuel and other nuclear materials in our fleet of NAC-LWT casks, NAC has proven experience and technology to develop new designs for transporting fuels for advanced reactors. With shielding, lifting, and securing options, our OPTIMUS® line of packages maximizes flexibility and lowers customer costs while transporting varied contents, from RH TRU and spent fuel to LLRW, CH TRU and MLLW.

MAGNASTOR® MEANS PROVEN, RELIABLE ULTRA-HIGH CAPACITY USED FUEL MANAGEMENT

For over 50 years, NAC International has been a trusted partner for fuel cycle management solutions and consulting.

NAC INTERNATIONAL
www.nacintl.com

CONTACT US:
George Vaughan, Vice President of Business Development
T: 770.447.1144 | gvaughan@nacintl.com

NAC LPT— Packaging Solutions for Radioactive Waste and More
NAC LPT offers best-value technical strategies and plans for logistics, packaging, and disposal, delivering equipment from a fleet of IP-1 intermodal containers, IP-1 gondola railcars, and ABC railcars for LLRW and hazardous material shipments. Our experts provide impartial, comprehensive waste management plans for government and commercial projects.

Spent Fuel Storage Systems
MAGNASTOR® is NAC's high-capacity (37 PWR or 89 BWR fuel assemblies) workhorse for spent fuel storage, with flexibility to be tailored for each site's spent fuel offloading requirements. Used at both decommissioning and operating nuclear plant sites, this system offers demonstrated loading efficiency to increase personnel safety and reduce cost and risk. Our team recently completed loading of a 37 PWR system in record time. NAC has delivered over 700 transportable spent fuel storage systems worldwide, with industry-leading system designs and packaging solutions.

Nuclear Fuel Cycle Expertise to Address Client-Specific Needs
NAC offers insightful and current training seminars, reports, and analyses on subjects important to the nuclear industry. Our internationally recognized network of industry experts combines worldwide industrial experience with global reach, detailed market analysis capabilities, and deep technical expertise. NAC's nuclear material control and accountability services and products support governments and nuclear facilities with customized tools for tracking, accountancy, obligations reporting, and safeguards. NAC's Reporter® system has been selected by international companies and government agencies.

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**:

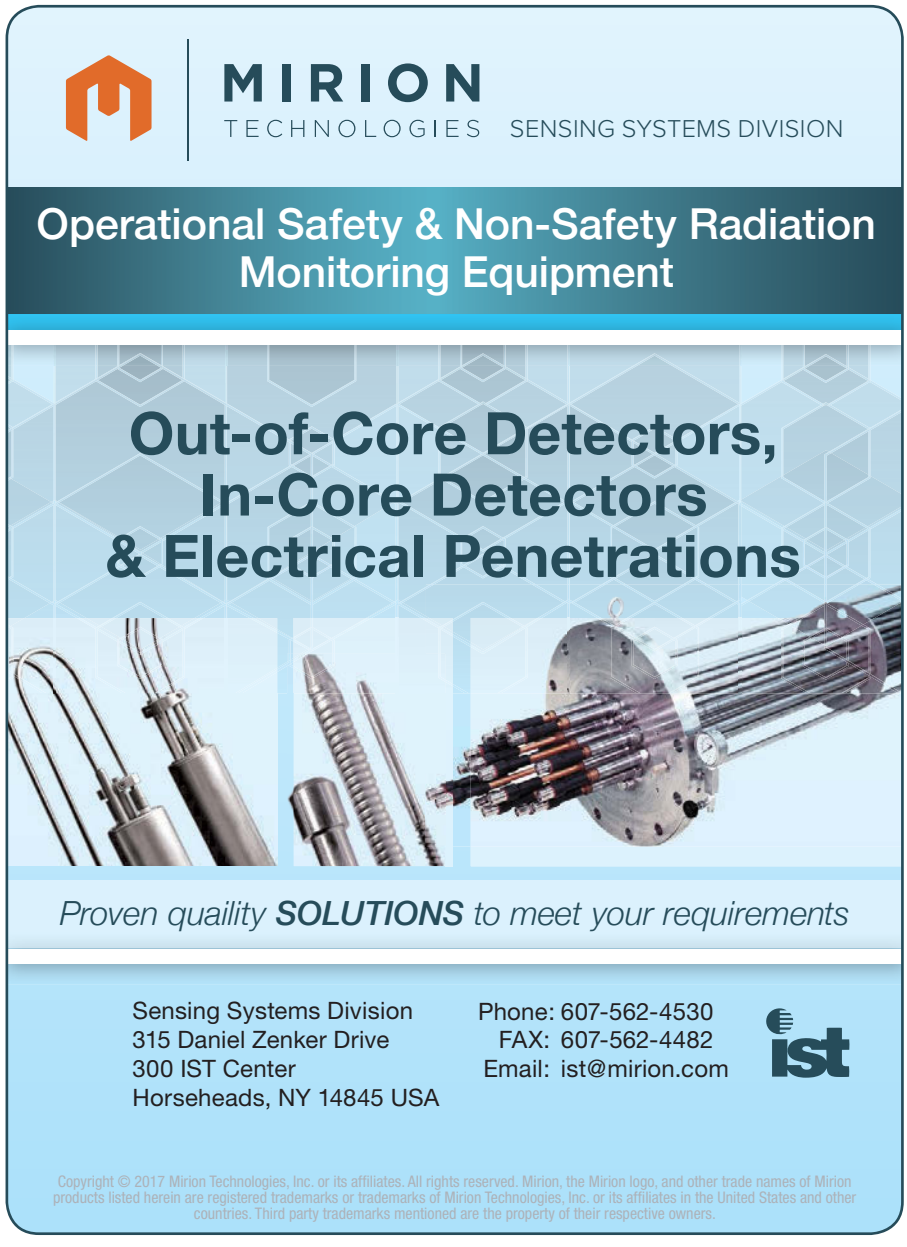
- Health Physics
- Radiation Monitoring Systems
- Spectroscopy
- Characterization
- Dosimetry Services
- Sensing Systems

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.**



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

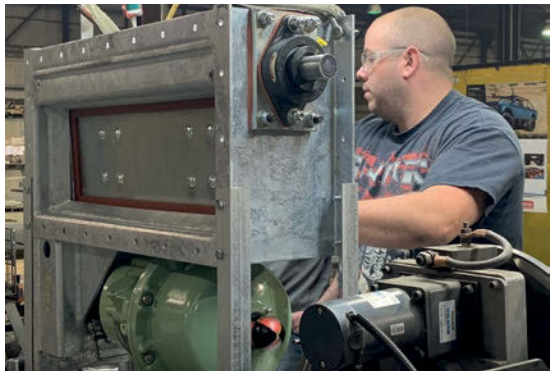
SSM INDUSTRIES, INC.
3401 Grand Avenue, Pittsburgh, PA 15255, USA
E: mgorman@ssmi.biz
W: www.ssmi.biz

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



BLUE WAVE AI LABS

See us at the ANS Utility Working Conference, Drop by booth #501

August 7 – 10 | Marco Island, FL

Powering the Nuclear Fleet with Artificial Intelligence

New to the scene in 2016, but already trusted by over half the BWRs in the U.S. domestic fleet, Blue Wave AI Labs is an AI-centric, industry-focused innovator with main headquarters at Purdue Research Park in West Lafayette, IN.

We are pioneering the use of AI and machine learning in nuclear power operations to provide more accurate projections and deeper insights. Our physics-constrained process leverages existing plant data to help reclaim unnecessary design margin and reduce operational challenges during the fuel cycle.

Meet our Interns

Gautham Vinod, *Mechanical Engineering PhD student, Purdue University*. Gautham is currently working to quantify model uncertainty and build new levels of trustworthiness into our AI.

Rizki Oktavian, Nuclear Engineering PhD student, Purdue University.

Rizki is using artificial intelligence to improve the accuracy and speed of real world full-core simulations.

Maniesha Singh, Nuclear Engineering PhD student, Purdue University.

Isha is developing economic models linking fuel costs with reload batch size, enrichment, and cycle length for BWRs.

Shuo Wang, Engineering and Technology Master's student in AI, Purdue University.

Shuo is using AI and natural language processing (NLP) to classify incident reports to identify problem components from unstructured data.

Gautham warming up with his Rubik's cube before running a new model.

Rizki getting ready for his PHYSOR 2022 presentation. ***Congrats*** *on the award for best paper at the ANS student conference!!*

Shuo practicing real world gradient descent!

Isha, speeding to the office!

www.bluewaveAILabs.com

Deepen, Optimize, Deliver. It's all about the future of clean energy.

A new energy landscape is taking shape. Power generation customers are focused on elevating plant performance which is an integral component to staying competitive in the emerging clean energy future. They are looking for new ways to optimize existing generation assets, align with new advanced technologies and designs, and integrate with renewable power sources to achieve these goals.

GSE's mission is to deliver advanced engineering and flexible workforce solutions that support nuclear power as being critical to clean energy production and overall decarbonization of the power industry.

Our solutions get the results you need. To reduce costs, improve performance, gain efficiency, reduce overhead, coordinate staff and leadership, fill gaps in knowledge or personnel, and realize opportunities for capitalization. We are your time-tested partner, committed to doing what's best for your station.

Deepen Your Existing Assets.
Maximizing power production is instrumental in helping facilities face current competitive pressures and find cost savings. We partner with our customers to actively explore, evaluate, and develop new solutions that optimize their core strengths and support their goals.

Optimize Using New Technology.
As we focus on clean energy production, GSE is ready to aggressively extend capabilities through a customized approach. Integrating our new technologies with existing plant requirements, alignment with deployment of advanced reactor designs and coordination with other renewable power sources will help customers achieve decarbonization of the grid by 2035.

Fill Operational Gaps Fast.
GSE Workforce Solutions division meets your operational needs with the right people and skills to run smoothly. Our placement experts identify solutions and talent that address workforce gaps and support your staff development goals.

GSE supports all phases of a station's life cycle, from problem evaluation and conceptual design, to budget, planning and controls, to engineering, implementation and close out. Our work helps optimize performance with powerful analytic programs that spot weaknesses and opportunities, and help to generate more energy, reliably and efficiency.

GSE select services and products include:

- Design Engineering Services
- Simulation Systems & Application
- Thermal Performance Optimization
- Engineering Program Expertise
- Specialized Consulting
- Nuclear Training Courses & Accreditation
- Staff Augmentation

If you need it, we can do it. There's a GSE solution for your every operations need.
www.gses.com

Delivering Advanced Engineering & Workforce Solutions That Matter.

Plant Performance Optimization

Improve ROI, Efficiency & Performance

- Engineering modifications and design
- Simulation: Training, Testing, Scenarios
- Engineering program applications
- Thermal performance solutions

Technical Staffing & Training

Over 50 Years of Power Expertise

- Flexible workforce solutions
- Fill your project and staffing needs fast
- Comprehensive training programs
- Extensive network of professionals

WMG Nuclear Services

Recognized **Leader** in Radwaste Management

Helping you succeed for over 40 years

PROFILE SUMMARY

Founded in 1979, and headquartered in Peekskill, New York, WMG provides the nuclear industry with professional nuclear engineering, waste management and software services. Anchored by our industry standard RADMAN™ Suite software for radioactive shipments, WMG has continued to provide innovative solutions to the industry's most complex challenges.

ENGINEERING

We pride ourselves as being the industry leader in providing defensible characterization and classification results.

We have the experience to know which analysis tool is appropriate for any shielding calculation.

We apply 200+ years of collective staff nuclear industry experience in our approach to solving unique waste management challenges.

We are an experienced designer and supplier of packaging that is compliant with the applicable NRC and DOT regulations.

SHIPPING SUPPORT

As the average age of utility personnel continues to rise, the resource pool of qualified radioactive waste managers and shippers is shrinking. WMG's Subject Matter Expert (SME), ProShipper™ and Shipping Command Center support services bring a practical solution to filling gaps in a utility's radwaste workforce.

Customers can opt for on-site or off-site shipper support as appropriate to fit operational needs.

WMG's broad spectrum of experience provides our clients with a reliable and efficient resource to help manage their most challenging radioactive waste issues. We have the expertise to ensure projects are completed.

SOFTWARE

WMG is committed to providing the best possible solutions for our customers' software needs. Our trusted solutions have been the industry standard for over 40 years. Our RADMAN™ Platform is utilized at nearly every U.S. nuclear power station, many radwaste processors, disposal facilities, government labs, state agencies and other industry supporting businesses.

The RADMAN™ Platform is now more powerful with the integration of the RADMAN™ Enhanced Accuracy Characterization, or REACh™ Detector System . Waste characterization just got easier - discover the difference with REACh™

To this day, through decades of industry and regulatory changes, the RADMAN™ Platform is still the standard and remains the only NRC approved application for the characterization of radioactive material.

TRAINING

WMG has been training industry technicians and professionals for over 30 years. Each course is delivered to the student by seasoned and highly experienced shippers.

Our courses, both standard and customized, are comprehensive, structured and meet the training requirements established by NRC IE Bulletin 79-19 and 49 CFR Part 172, Subpart H. Our courses can be taught at the client's facility, or at regional locations.

CONTACT

16 Bank Street
Peekskill, NY 10566

914.736.7100

info@wmginc.com

www.wmginc.com

TRUST

Trust is fragile. It is difficult to earn and easy to lose. As our industry has evolved, companies have come and gone, yet WMG continues to thrive, in large part because of the trust our clients have in our capabilities. Our success is entirely dependent upon your success.

Recent years have put increased pressure on our industry, and we are all asked to do more with less in the name of survival. Experienced professionals are retiring from the industry and in many cases, this process knowledge and expertise isn't being replaced.

As a proud, independent, family-owned small business, specializing in software, engineering, characterization and management of radioactive material, our employees have always been our greatest asset. Our employees are recognized experts in the industry and highly respected by clients, competitors, regulators and industry groups for their capabilities and experience.

Even with all of the new challenges we face, our mission of providing excellence in radioactive waste management through service, innovation, value and integrity remains unchanged, and more important than ever.

Allow us the opportunity to earn your trust and we will show you what it means to have a partner in the industry that is just as committed to your success as you are.

Sincerely,
Kevin Tuite
President and CEO
WMG, Inc.

Service... Innovation... Value... Integrity...

Service... Innovation... Value... Integrity...

Recognized **Leader** in Radwaste Management

Helping you succeed for over 40 years

ABOUT OUR COMPANY

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GET IN TOUCH

16 Bank Street, Peekskill, NY 10566
914.736.7100

www.wmginc.com
info@wmginc.com

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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®

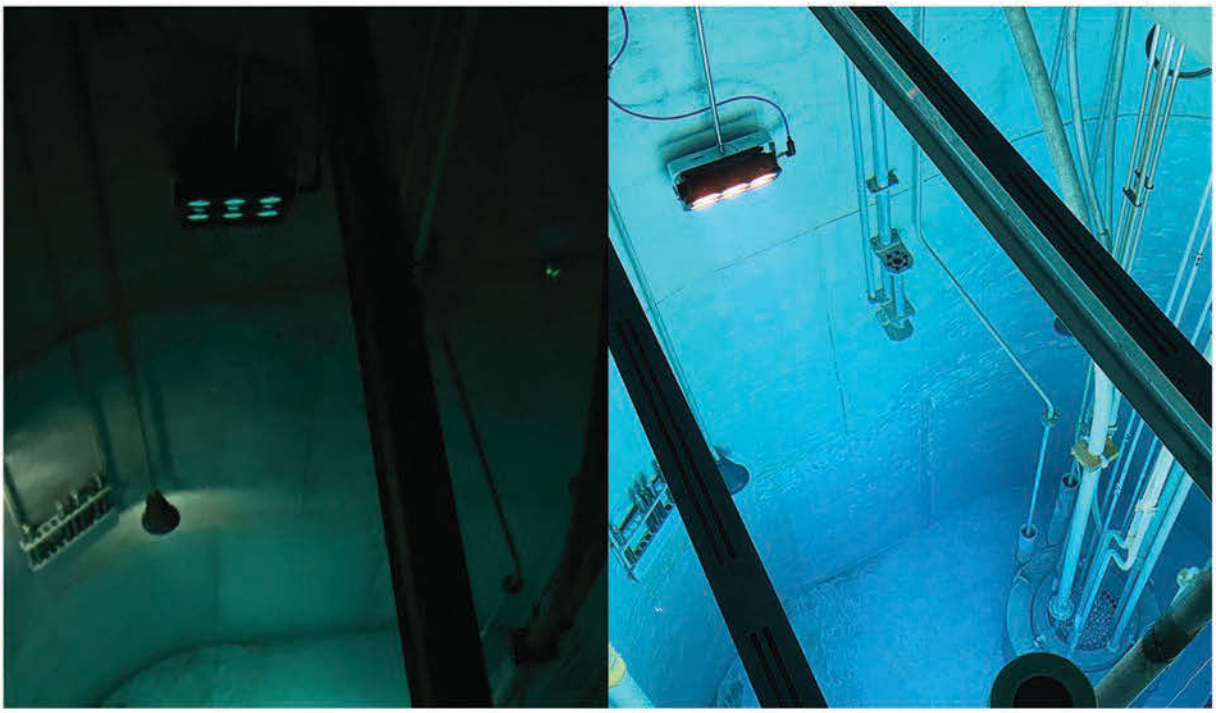
Brokk Inc. | 1144 Village Way, Monroe WA | Tel.: 360 794 1277 | info@brokkinc.com | www.brokk.com/us

Innovating Nuclear Lighting for Five Decades

BIRNS has been a trusted leader in the development of powerful and unique lighting technologies since the 1970s. Over the years we've lowered nuclear power plant operating costs and increased safety by illuminating the toughest jobs in the plant—from reactor cores, fuel pools and hallways to polar crane high bays and mezzanine low bays. Every BIRNS floodlight, Emergency Light Fixture, drop light and bay light is designed to exceed industry requirements, perform efficiently, minimize radwaste, and improve productivity and safety.

The difference is like night and day...

That's what we're hearing from our customers using the new BIRNS Lumena-6™ LED floodlight. The 85,000 lumen BIRNS Lumena-6 is an advanced, brilliant underwater LED system that reduces nuclear fuel handling costs and enhances safety by bringing daylight visibility to a range of pools inside containment. This plug-and-play lighting solution offers flexibility and simplicity, featuring an integrated onboard water cooled power driver, so a single mains power outlet is all that is needed on the surface. It features an 80,000 hour lamp life and ultra-high efficiency reflectors, with either spot or flood options.



BIRNS®

High Performance . . . Under Pressure®

www.birns.com

QUALITY SYSTEM CERTIFICATION DNV ISO 9001

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

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

World Calibrator
VFD Version
± 1% F.S. Accuracy
PC Interfaceable

DF-ABM50-75L-20Li
Indoor/Outdoor
Emergency Response Air Sampler

HV-1V.2
Portable
High Volume Air Sampler

DF-ERHV-DT
High Volume Emergency Response
Air Sampling System
(8” x 10” Filter)

Filter Holders
Plastic, Stainless Steel, Aluminum

Personal Air Samplers

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

Energy Steel: Committed to the needs of the nuclear industry since 1982

Backed by 40 years of experience, Energy Steel supports nuclear equipment supply around the globe through high-quality products and OEM parts, engineering services, repairs, and on-site support.

We carry certifications in ASME N, NPT, NA, NS, U and NBIC R and NR, and we specialize in safety-related/ASME Section III products that span a wide range of sizes and applications.

Heat Exchangers

Our extensive knowledge and experience includes custom design, repairs, and performance evaluation reporting. We can supply **Graham** heat exchangers.

Pumps & Motors

We have expertise in sealed and sealless pumps and motors for the most complex nuclear applications. We can supply **Crane** and **APV Gaulin** pumps.

Greer Accumulators

We are the authorized manufacturer of Greer Bladder Accumulators – the most reliable on the market today. They improve system efficiency with dependable performance and service life.

Valves

We offer commercial-grade, safety-related, and ASME Section III valves, including new and replacement units, for a wide range of nuclear applications. We can supply **WKM** valves.

Tanks & Pressure Vessels

From lube oil tanks to water separation tanks, we tackle all types of vessel projects at nuclear facilities.

Structural Supports

We provide precision fabrication of structural supports of any size, including engineered solutions and build-to-print custom fabrication.

Filters & Strainers

We offer a range of filters and strainers that protect your equipment, including Simplex, Duplex and Y Type. We can supply **Zurn** strainers.

Specialty Components

Our wide range of innovative solutions includes spent fuel canister components, custom valve bodies, straining elements, fasteners, and studs.

Heritage Products

We specialize in the refurbishment and replacement of obsolete parts, such as heat exchangers, pumps, valves and filters. We offer custom fabrication solutions, design services, performance evaluation reporting, design verification and re-rating.

energysteel 40 YEARS

accelerant solutions

WHO WE ARE

Accelerant Solutions has been assisting its nuclear power industry clients, both in the US and internationally, since 2003, with managing important projects to achieve operational excellence in nuclear power. Today, we maintain working partnerships with 24 of the 28 American utilities that operate nuclear power plants.

Training

You can rely on us for training program design and optimization, knowledge retention programs, lesson material development and upgrades, enhanced learning tools, training program compliance assessments, crew resource management diagnostics and workshops, and supplemental instructor staffing.

We have a team of experienced and highly qualified supplemental nuclear power technical experts to assist and mentor personnel in plant leadership, operations, engineering, training, maintenance, work management, and performance improvement.

Compliance

We work with regulatory compliance and enforcement recovery, new plant start-up readiness assurance, procedure creation and validation, computerized procedure systems, event investigations, corrective action program design, and safety culture diagnostics and improvements.

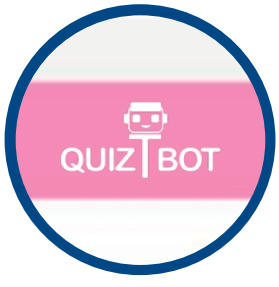
Accelerant Solutions is uniquely equipped to meet the unique needs of any industry or company wanting to achieve operational excellence.

Innovation

Our innovation techniques transfer knowledge and lower attrition using simple content management that works. We explore and utilize cutting edge technology such as artificial intelligence, virtual reality, and cloud-computing assist to enhance the human experience and reduce the time required to update and revise training material. The automation of menial tasks reduces cost, eliminates errors, and empowers your team members.

INNOVATION

Your trusted partner for training platforms and technologies, performance improvement, and SAT-based training programs.



Visit discoveraccelerant.com/innovation.com to learn more.

accelerant solutions

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.

TEI COMMITTED TO AMERICAN EXCELLENCE IN DESIGN & MANUFACTURING

Thermal Engineering International (TEi), a Babcock Power company, has been a leading supplier of heat transfer technology for power generation, oil, gas and chemical industries since 1916 and a trusted partner to the nuclear industry since 1964. The innovator of notable "firsts" — including the introduction of advanced MSR technology for the early nuclear plants — the company continues to seek new products and methods to improve daily operations and to position the industry for the future.

TEi offers a full range of cutting-edge solutions from designing, manufacturing and installation of new systems to engineering consulting and equipment upgrades. With a product lineup comprised of MSRs, SMRs, feedwater heaters, steam surface condensers, condenser modules and heat exchangers for a wide variety of applications, TEi has placed a key priority on highly demanding and large nuclear projects. We are proud to manufacture our heat transfer equipment in the USA.

As part of its commitment to excellence in quality manufacturing and service support for domestic customers, TEi maintains a state-of-the-art manufacturing facility equipped with sophisticated tooling for fabricating the multiple vessels associated with heat transfer equipment.

TEi's Joplin Facility

Occupying twenty acres of land in Joplin, Missouri, TEi's in-house fabrication plant and has been expanded with state-of-the-art overhead cranes with 200 tons of lifting capacity, railroad loading and unloading access. The addition provides the extra footprint required to accommodate the 'Supertanker' MSR designs and provides TEi with a secure facility to house the expertise and quality of workmanship needed to build this equipment.

Feedwater Heater Fabrication

Condenser Fabrication

MSR Supertanker Shell Fabrication

"Because manufacturing in the US requires a higher standard than other areas of the world, 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.

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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.

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Find out what Industry Leaders already know

"Exelon's VR training environment allows the technicians to practice in a safe environment, increasing their proficiency so they may perform work effectively while also reducing exposure when repairs are needed."

—Marvin Burdick, *Corporate M&T Training Manager*, Exelon

VR reduces mockup building and storage costs, but also more closely matches a real environment both in scale and surroundings. "Your brain is convincing you that you are in that location."

—Jonathan Scruggs, *Vice President of Non-destructive Examination Solutions*, Framatome

VR is seeing "huge, huge uptake" among nuclear operators.

— Kevin Lee, *Senior Regulatory Policy Officer*, Canadian Nuclear Safety Commission (CNSC)

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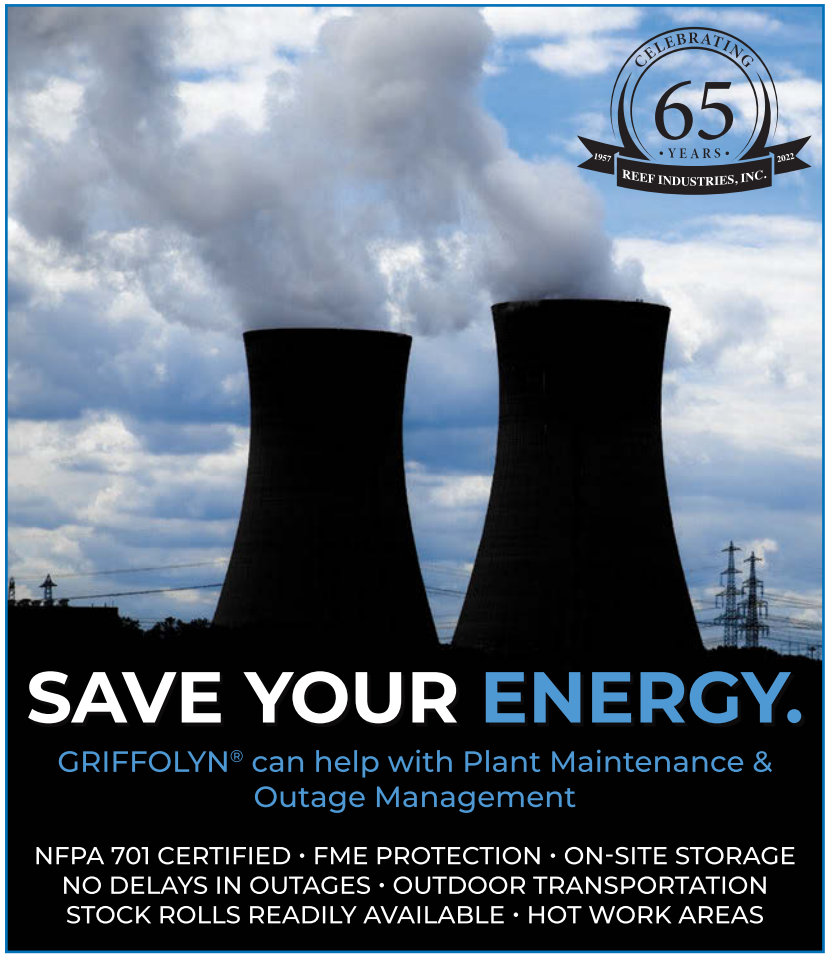

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2	S-533L	1	M-305	1	TR-6590N
2	S-533S	1	M-307	1	TR-6820N
2	S-433L-5	1	M-405	1	TR-6510N
2	S-433S-5	1	M-407	1	TR-6530N
1	S-103L-20			1	TR-6320N
1	S-103S-20			1	TR-6360N
1	S-403L-20			1	TR-6350N
1	S-403S-20				
1	S-605-10				
1	S-607-10				
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DOE revises nuclear credit program guidance, extends application deadline

The Department of Energy announced that it has amended its Civil Nuclear Credit (CNC) Program guidance for the currently open award cycle and extended the deadline for credit applications from July 5 to September 6. The DOE was instructed to establish the $6 billion program by the Infrastructure Investment and Jobs Act, signed into law by President Biden last November.

The original guidance for the program was published in April, but on June 17 the DOE issued a request for public input on a proposed amendment after receiving a letter from California Gov. Gavin Newsom's office expressing a newfound interest in keeping the state's Diablo Canyon nuclear plant in operation past its scheduled 2025 retirement date. The Newsom letter requested three changes to the language of the CNC Program guidance in order to ensure that the plant—California's sole operating nuclear power facility—would qualify for credits.

With its amended guidance, the DOE has granted one of Newsom's requests: the removal of the requirement that a nuclear reactor applying for credits under the CNC Program not recover more than 50 percent of its costs from cost-of-service regulation or regulated contracts.

The department's extension to the deadline for credit applications can be seen as a response to a June 27 letter from California utility Pacific Gas and Electric, Diablo Canyon's owner and operator. In that letter, the company's vice president of federal affairs, Yvonne McIntyre, endorsed the proposed amendment but requested an additional 75 days to prepare an application. "The application requires a significant amount of detailed information, and given the recent direction from the governor, an extension is needed to provide PG&E the time to collect and analyze the information and prepare an application," she wrote.

In its June 30 announcement, the DOE said that 60 days would provide applicants sufficient time to prepare submissions.

A good day for Diablo

Also on June 30, Newsom signed a bill that could potentially provide funding for operations at Diablo Canyon beyond 2025. Some of Southern California's fossil fuel plants are in line for possible life extension under the measure, as well.

The legislation—which aims to strengthen a grid that many would say is overly reliant on renewables—includes an energy trailer bill that allocates a reserve fund of up to $75 million to California's Department of Water Resources to prolong the operation of power plants scheduled for closure.

As noted in a June 29 *Cal Matters* report, "While it's true that the energy bill doesn't itself authorize the extension of [Diablo Canyon's] life, it does provide the money should state leaders decide to do so. Such a move would require 'subsequent legislation and review and approval by state, local, and federal regulatory entities,' said Lindsay Buckley, a spokesperson for the California Energy Commission."

Following passage of the bill on June 29,

ANS President Steven Arndt and Executive Director/CEO Craig Piercy issued a statement applauding the lawmakers and thanking Newsom "for his support and reconsideration of the state's decision to prematurely shutter California's largest clean energy resource."

The statement continued: "California doesn't have enough reliable electricity resources today to keep the lights on. The future loss of Diablo Canyon's carbon-free baseload power would significantly worsen California's energy crisis. Keeping Diablo Canyon on line would shore up California's grid reliability while avoiding increased emissions. Action is needed now to ensure Diablo Canyon's availability in the future."

POLICY

U.S. to provide $14 million for Romanian SMR study

At the recent G7 summit in Germany, President Biden and other world leaders launched the Partnership for Global Infrastructure and Investment—described by the State Department as an effort "to narrow infrastructure gaps around the world, strengthen the global economy and supply chains, and advance international security through strategic investments."

Included among the partnership's projects is a $14 million U.S. commitment toward a front-end engineering and design (FEED) study to provide site-specific data necessary for the deployment of a small modular reactor plant in Romania, including cost, construction, schedule, and licensing details.

This project, according to State, is the next step in a plan that first came to light on the sidelines of the COP26 Conference in Glasgow last November, when John Kerry, the Biden administration's special presidential envoy for climate, and Romanian president Klaus Iohannis proposed the deployment of an SMR facility in the Eastern European nation using NuScale Power technology.

The study is expected to take eight months and cost a total of $28 million, with contributions from NuScale and the state-owned Romanian utility Nuclearelectrica. Technical assistance is to be provided by the U.S. Trade and Development Agency and the Commerce Department.

"Our partners in Romania and across Eastern Europe require the scaling of existing project preparation efforts to meet the region's longer-term energy security needs," said Enoh T. Ebong, USTDA director. "This FEED study would build upon USTDA's existing commitments to deploy cutting-edge U.S. SMR solutions to the region, including grant funding for a study that helped Romania identify and assess several locations where existing coal-fired power plants could be replaced with SMR plants. Our engagement is having the intended result of creating new business opportunities for U.S. industry in an important market and advancing energy security across the region."

President Biden and the G7 leaders on day two of the G7 conference. (Photo: White House Twitter)

John Hopkins, NuScale's president and chief executive officer, said, "When future generations look back at this time, they will see that we came together to ensure that we are accelerating technology that can fight climate change and provide energy security. NuScale's partnership with Romania's Nuclearelectrica to deploy our VOYGR-6 SMR power plant will create jobs and energy independence while ensuring a better tomorrow, and we thank the U.S. government for its crucial support for this project."

Power & Operations continues

GRAND GULF

Entergy settles with state PSC for $300M over plant rate issues

The Mississippi Public Services Commission has announced a $300 million settlement with Entergy Mississippi—the largest settlement in the MPSC's history—ending the state's part in multistate Federal Energy Regulatory Commission proceedings involving Grand Gulf plant customer rate impacts.

Located in Port Gibson, Miss., Grand Gulf houses a 1,433-MWe boiling water reactor that began commercial operation in 1985. Entergy Corporation owns 90 percent of the facility under its System Energy Resources subsidiary.

According to the June 23 announcement, the MPSC began the litigation before FERC in 2017 over "certain accounting and financing aspects of the Grand Gulf Nuclear Power Station that produced today's settlement. . . . This global settlement for the state of Mississippi will deliver expeditious benefits to Entergy Mississippi's customers through refunds and prospective rate reductions, plus decrease regulatory uncertainty at [Grand Gulf]."

The Grand Gulf nuclear power plant in Port Gibson, Miss. (Photo: Entergy)

Results of the settlement with Entergy Mississippi include:

- $200 million to offset high natural gas prices caused by global spikes in energy markets. (Without the infusion of $200 million, the utility's customers would have seen an increase of greater than $15 a month beginning in January 2023, the MPSC said.)
- $35 million for a one-time bill credit, or check, of approximately $80 for each customer.
- $65 million to be issued through the coming years in the form of lower bills.

"I thank my colleagues and the commission's staff for the hard work that resulted in this historic settlement," said MPSC commissioner Brandon Presley. "To be able to send cash back to Mississippians at a time when they are being hit with high gasoline prices at the pump and inflation at every turn is one of my proudest achievements as a public service commissioner. In a global energy crisis, we have taken the lead to brunt these effects, as much as possible, and provide long-term and short-term financial benefits to our people. We will continue to hunt in every nook and cranny for ways to save Mississippians money and hold utility companies accountable."

In its own announcement on the settlement, Entergy noted that while it maintains its position on the issues in dispute at FERC, the ongoing cost of the proceedings and the uncertainty it created for customers, employees, and stockholders led the company to seek a resolution. "While no settlement is perfect for all parties involved, we applaud the Mississippi commissioners for taking this action," Haley Fisackerly, Entergy Mississippi president and chief executive officer, said. "They recognized the need to represent their constituents' interests while at the same time securing the long-term future of a vital resource to Mississippi consumers and Mississippi's economy."

CANADA

Saskatchewan picks BWRX-300 for potential deployment

Following an assessment of several small modular reactor technologies, SaskPower has chosen GE Hitachi Nuclear Energy's (GEH's) BWRX-300 SMR for potential deployment in Saskatchewan in the mid-2030s, the Canadian utility announced on June 27.

The assessment process focused on a number of factors, according to the announcement, including safety, technology readiness, generation size, fuel type, and expected cost of electricity. In addition, the assessment involved a collaboration with Ontario Power Generation, which last December selected the BWRX-300 as the SMR technology to be deployed at its Darlington nuclear plant.

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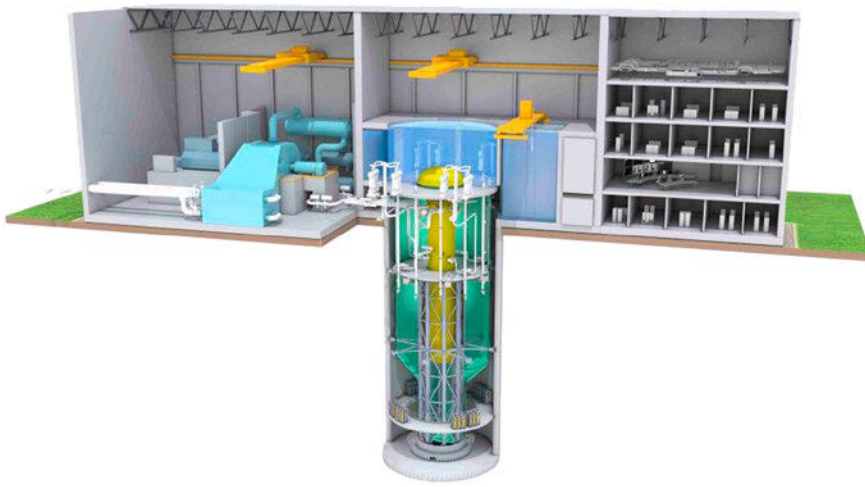

A cutaway image of the BWRX-300. (Image: GE Hitachi Nuclear Energy)

SaskPower said that its selection of the same technology helps enable a pan-Canadian fleet-based approach to SMR deployment, which can offer many advantages—such as lower regulatory, construction, and operating costs—while eliminating first-of-a-kind risk.

Although it's currently conducting a detailed technical evaluation of potential regions that could host an SMR, SaskPower will not make a final decision regarding construction in Saskatchewan until 2029, the announcement stated.

"Today marks the beginning of an exciting relationship between SaskPower and GE Hitachi, a leader in the nuclear energy field that has the potential to benefit SaskPower and Saskatchewan for many decades to come," declared Troy King, interim president and chief executive officer at SaskPower. "We are committed to reducing our greenhouse gas emissions while providing safe, reliable, and sustainable power for our customers, and GE Hitachi's SMR technology could play a powerful role in this future."

"We are excited that SaskPower has chosen our technology as it looks to SMRs for the generation of carbon-free electricity," said Jay Wileman, GEH president and CEO. "We believe the BWRX-300 is an ideal solution for SaskPower and customers that want to make an impact on climate change and energy security in a meaningful time frame. Decades of design and licensing experience coupled with our proven and existing fuel supply chain position the BWRX-300 as the leading SMR solution."

CNSC renews Point Lepreau license for 10 years

The Canadian Nuclear Safety Commission has renewed the operating license of the reactor at the Point Lepreau nuclear plant for a period of 10 years. As a result, the facility's 660-MWe CANDU-6 unit, the five-year license for which was set to expire on June 30, is now sanctioned to operate until the end of June 2032. License holder NB Power had requested an unprecedented 25-year extension.

Located on the shores of the Bay of Fundy in New Brunswick, Point Lepreau began commercial operation in 1983. It is Atlantic Canada's only nuclear power generating station, providing New Brunswick with about 35 percent of its electricity.

Point Lepreau nuclear power plant. (Photo: NB Power)

The CNSC announced its decision on June 22, following a two-part public hearing held in January and May of this year in Saint John, New Brunswick. According to the announcement, oral and written submissions from NB Power, CNSC staff, and 243 intervenors were considered. The commission also made participant funding available through its Participant Funding Program and invited interventions from Indigenous Nations and communities, members of the public, and stakeholders.

"Regarding NB Power's request for a 25-year license, the commission concluded that a 10-year license was appropriate, noting factors such as the strong public interest in the hearing process and the need to advance reconciliation with Indigenous Nations and communities," the CNSC stated in its announcement. "In addition, the commission has directed NB Power and CNSC staff to each present a comprehensive update to the commission on the licensed activities at [Point Lepreau], including key issues raised during the hearing, at the mid-point of the 10-year license term. This update will take place at a meeting conducted in the

In Case You Missed It . . .

Although previously a supporter of Diablo Canyon's early closure, California Sen. Dianne Feinstein took to the pages of the *Sacramento Bee* on June 15 to endorse life extension for the state's only operating nuclear power plant. Citing projected electricity shortfalls in California due to the effects of climate change, Feinstein writes that "Pacific Gas and Electric Company should reconsider its decision to close Diablo Canyon by 2025. The utility should get the plant relicensed instead, retiring it once the state can replace its production with clean sources. . . . I remain concerned about the lack of long-term storage for spent nuclear fuel and am working to develop better solutions. But at this point, keeping Diablo Canyon open and producing carbon-free energy is more important."

Feinstein

BWX Technologies will deliver the first microreactor in the United States under a contract awarded by the U.S. Department of Defense Strategic Capabilities Office (SCO), the company announced on June 9. BWXT will have two years to build a transportable microreactor prototype to the SCO's Project Pele specifications and deliver it to Idaho National Laboratory for testing under a cost-type contract valued at about $300 million. The SCO is working with the Department of Energy to develop, prototype, and demonstrate a microreactor that can provide a resilient power source for operational needs that have historically relied on fossil fuels. The SCO released a record of decision on April 13 to proceed with Project Pele after a final environmental impact statement was published in February.

Artist's rendering of BWXT's Project Pele transportable reactor modules arriving for setup and operation. (Image: BWXT)

The SCO first published a request for solutions in 2019 seeking a transportable reactor that could be quickly started up, shut down, and relocated to deliver clean, reliable energy when and where it is required, without reliance on extensive fossil fuel supply chains. A microreactor built to those specifications could also meet commercial needs for disaster response and recovery and power generation at remote locations.

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

community in proximity to [the plant] and will allow for the participation of members of the public and Indigenous Nations and communities."

NB Power's chief nuclear officer, Brett Plummer, said that the utility respected the CNSC's decision, adding, "This decision represents the longest-term license for Point Lepreau to date, and we are pleased. License renewal is a very thorough and balanced process, and we understand the many complex perspectives and attributes that are required to be carefully considered."

NRC

Applicant, licensee fees revised for FY 2022

The Nuclear Regulatory Commission published in the June 22 *Federal Register* a final rule amending the licensing, inspection, special projects, and annual fees it will charge applicants and licensees for fiscal year 2022. A proposed rule on the matter was published for public comment February 23.

The fee revisions, which go into effect August 22, are required by the Nuclear Energy Innovation and Modernization Act (NEIMA), the nuclear industry–backed legislation signed into law by President Trump in January 2019 (*Nuclear News*, Feb. 2019, p. 17). NEIMA requires the NRC to recover

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approximately 100 percent of its annual budget, less the budget authority for excluded activities. (Previously, the requirement was approximately 90 percent.) In addition, NEIMA established a new cap for annual fees for operating reactors and included requirements to improve the accuracy of invoice-for-service fees.

The FY 2022 final fee rule reflects a total budget authority of $887.7 million, an increase of $43.3 million from FY 2021. After accounting for exclusions from the fee-recovery requirement and net billing adjustments, the NRC must recover approximately $752.7 million in fees in FY 2022. Of this amount, an estimated $198.8 million is to be recovered through 10 CFR Part 170 fees for services and about $553.9 million through Part 171 annual fees.

Compared with FY 2021, annual fees are decreasing for fuel facilities, spent fuel storage/reactor decommissioning activities, and for a uranium recovery facility licensee. Fees are increasing, however, for operating power reactors, non-power production or utilization facilities, the U.S. Department of Energy Uranium Mill Tailings Radiation Control Act Program, DOE transportation activities, and for 47 materials-users fee categories. The power reactor fee, for instance, moves up from $4,749,000 to $5,165,000.

Also increasing is the agency's hourly rate for services. The FY 2022 rate is $290, a slight uptick (0.7 percent) from last year's $288.

FPL files report, asks for reinstatement of Turkey Point's 20-year SLR term

Florida Power & Light has submitted a supplemental environmental report to the Nuclear Regulatory Commission in support of the subsequent renewed licenses for Turkey Point Units 3 and 4. According to an NRC press release, FPL's report was submitted on June 10 to satisfy a "deficiency" in subsequent license renewal applications (SLRAs) that rely on the generic environmental impact statement (GEIS) on license renewal and is being reviewed prior to docketing. William D. Maher, director of nuclear licensing projects at FPL, submitted the report, noting that "FPL's review did not identify any information materially changing the impact assessments" in the NRC's supplemental GEIS for the Turkey Point licenses.

Turkey Point nuclear plant. (Image: FPL)

The NRC's approval of the SLRA for Turkey Point in December 2019 extended the reactor's expiration dates to July 2052 for Unit 3 and April 2053 for Unit 4, permitting a total of 80 years of operation.

The commission issued decisions on February 24, one of which concluded that the GEIS on license renewal analyzed only the environmental impacts of an initial 20-year license renewal term and did not apply to a subsequent renewal term. Because the environmental review of Turkey Point's subsequent renewed license relied on the GEIS, it was deemed incomplete.

A separate commission decision provided an option for license holders, including FPL, to provide additional environmental information on a site-specific basis, instead of waiting for NRC staff to revise the GEIS and complete a related rulemaking.

A June 3 memorandum and order from the commission affirmed that Turkey Point's subsequent renewed licenses remain in effect with altered due dates. The June 3 order stated in part that "since 2019, FPL has been operating under the subsequently renewed licenses, which include safety enhancements compared to the previous licenses. To best

reconcile FPL's current licensing bases with the recognition that the agency's National Environmental Policy Act (NEPA) review was incomplete, we directed that the subsequently renewed licenses remain in place but with shortened terms to match the end dates of the previous licenses until completion of the NEPA analysis."

FPL's Maher, in a cover letter accompanying the supplemental environmental report, stated that "neither the FPL ER [environmental report] nor the NRC supplemental GEIS identified any new and significant information related to the Turkey Point SLRA that would change any impact finding in the NRC's GEIS for the subsequent period of extended operation or otherwise render the analyses in the GEIS inapplicable to an evaluation of the Turkey Point subsequent period of extended operation."

He went on to explain that "FPL elected and completed a site-specific SLR environmental review of Turkey Point Units 3 and 4 operation[s], with the enclosed SLRA ER supplement addressing each previously generically addressed issue on a site-specific basis. This review confirmed that the environmental impact conclusions in NRC's 2013 GEIS for license renewal continue to bound operation of Turkey Point during the subsequent period of extended operation.

"FPL's review did not identify any information materially changing the impact assessments provided in the NRC's supplemental GEIS for the Turkey Point SLRA. Therefore, we expect that upon independent review of the site-specific information provided in the enclosed ER supplement, the NRC can expeditiously supplement its final GEIS for the Turkey Point SLRA to address the commission's direction in CLI-22-02 and restore the additional 20 years of operation provided by the 2019 subsequent renewed facility operating licenses."

Power & Operations continues

Barakah-3. (Photo: Nawah Energy Company)

UAE

Barakah-3 license issued; fuel loading starts

The United Arab Emirates' Federal Authority for Nuclear Regulation (FANR) has issued the operating license for the Barakah nuclear plant's Unit 3 reactor, the Emirates Nuclear Energy Corporation announced on June 19. In addition, following receipt of the license, ENEC subsidiary Nawah Energy Company began the process of loading fuel assemblies into the unit, according to the announcement.

Construction of Barakah-3 was completed in November of last year. Licensed to operate for 60 years, the reactor is scheduled to achieve initial criticality later in 2022 and begin commercial operation in 2023, joining Units 1 and 2, which entered service in April 2021 and this March, respectively.

"We look forward to the start of reliable electricity production alongside Units 1 and 2 in the coming months," stated Mohamed Ibrahim Al Hammadi, ENEC's managing director and chief executive officer, in the announcement. "As we count with Unit 3, we are rapidly delivering a practical climate solution on the ground, enabling the UAE's large-scale decarbonization efforts alongside its economic growth and leading the way to achieving net-zero emissions by 2050. The success and benefits of bringing each unit at Barakah into operation in consecutive years . . . showcase the significant benefits of developing a multi-unit nuclear energy plant in driving energy security and sustainability for nations that commit to the long-term development process of a civil nuclear program."

Nawah Energy CEO Ali Al Hammadi commented, "Receiving the third operating license for the Barakah plant is the result of over 520 rigorous reviews to date from our independent regulator, FANR, of which 120 are related specifically to Unit 3. The reviews cover every aspect of the plant to ensure we are ready to operate in line with national regulatory requirements. Successfully passing these reviews is testament to the expertise

we have developed and the outstanding operating experience of our teams, made up of highly skilled and qualified UAE nationals and international experts."

The UAE began a nuclear partnership with South Korea in 2009, when Korea Electric Power Corporation was awarded the prime contract to design, build, and help operate four 1,345-MWe APR1400 pressurized water reactors at Barakah, located in the Al Dhafra region of Abu Dhabi. In 2016, ENEC and KEPCO signed a joint venture agreement for a long-term partnership to become joint owners of Nawah and Barakah One Company, with ENEC owning 82 percent of the two firms and KEPCO holding an 18 percent ownership stake.

Construction of Barakah-4, according to FANR, is 92 percent complete. It is estimated that once all four units are in operation, the plant will supply approximately 25 percent of the UAE's electricity, while preventing 22.4 million tons of carbon emissions annually.

FINLAND

Olkiluoto-3 start pushed to end of year

Teollisuuden Voima Oyj (TVO), owner and operator of Finland's Olkiluoto nuclear power plant, has announced a further delay to the start of regular electricity generation at Unit 3. Commercial operation is now projected to begin this December, rather than the previously announced September. A report from Reuters put the date at December 10.

According to TVO, material that had detached from the steam guide plates was found in the turbine's steam reheater last month, requiring inspection and repair work.

"The repair work will last until the end of July," the company stated in a June 15 news release. "The plant unit's test production program and electricity production can only be continued after the completion of this repair work. Furthermore, additional time has been reserved in the schedule for the plant unit's upcoming tests and their analyses, based on previous experiences from the test production phase."

Olkiluoto-3 was connected to Finland's power grid on March 12 of this year. At the time, TVO projected that commercial operation would begin in late July. In April, however, the company announced a postponement to September, due to inspection and repair needs regarding the cooling system of the unit's generator.

Finland's Olkiluoto-3. (Photo: TVO)

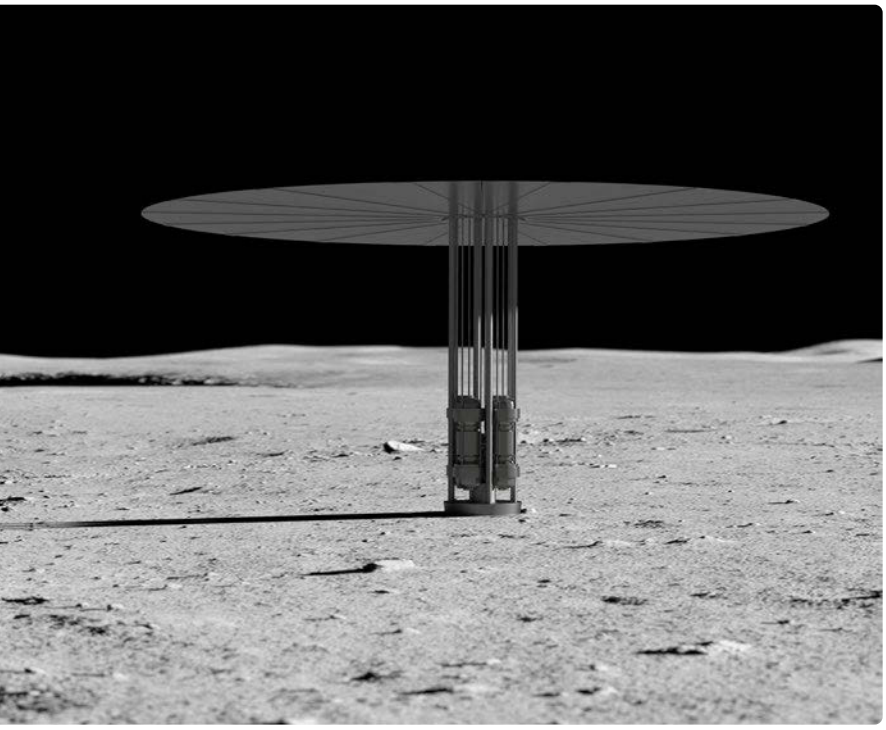
Europe's first EPR, the Framatome-supplied, 1,600-MWe Generation III+ Unit 3 is also the first new Finnish reactor in four decades and one of only three new reactors in Europe in the past 15 years. (Romania's Cernavoda-2 began supplying electricity to the grid in August 2007, and Belarus's Belarusian-1 in November 2020.) Once up and running, Olkiluoto-3 is expected to produce approximately 14 percent of Finland's electricity demand.

Located in western Finland, Olkiluoto also houses two 890-MWe boiling water reactors. Units 1 and 2 began commercial operation in October 1979 and July 1982, respectively.

Nuclear power's moonshot: Three teams have one year to design a lunar power reactor

A fission surface power project sponsored by NASA in collaboration with the Department of Energy and Idaho National Laboratory is targeting the demonstration of a 40-kWe reactor built to operate for at least 10 years on the moon, enabling lunar exploration under NASA's Artemis program by the end of the decade. NASA and INL announced June 21 that 12-month contracts valued at $5 million each would go to Lockheed Martin (partnered with BWX Technologies and Creare), Westinghouse (partnered with Aerojet Rocketdyne), and IX (a joint venture of Intuitive Machines and X-energy, partnered with Maxar and Boeing).

Battelle Energy Alliance (BEA), the managing and operating contractor for INL, initiated a Phase 1 request for proposal process sponsored by NASA in November 2021. INL evaluated the proposals and is distributing the awards for the Phase 1 initial design effort.



A conceptual illustration of a fission surface power system. (Image: NASA)

Specifications in the Phase 1 RFP included a minimum end-of-life 40-kWe continuous power output for at least 10 years (higher power ratings are "desirable"), a system that fits within a stowed cylinder measuring 4 meters in diameter and 6 meters in length, a total system mass that does not exceed 6 metric tons, and autonomous operation from the deck of a lunar lander or from a separate mobile system that permits the reactor to be moved to another lunar site.

While the Phase 1 teams will receive firm, fixed-price awards, Phase 2 is likely to be a cost-type arrangement with a separate set of criteria evaluated "following a best-value method, where the best combination of technical advantage and cost/price reasonableness will determine award selection," according to the Phase 1 RFP. BEA expects to issue an RFP for follow-on Phase 2 activities after Phase 1 is complete.

The Phase 1 awards will provide NASA critical information from industry that could lead to a full flight-certified fission power system. Fission surface power technologies also will help NASA mature nuclear propulsion systems.

NASA's fission surface power project is managed by the agency's Glenn Research Center in Cleveland, Ohio, and the power system development is funded by the Space Technology Mission Directorate's Technology Demonstration Missions program at Marshall Space Flight Center in Huntsville, Ala.

FUSION

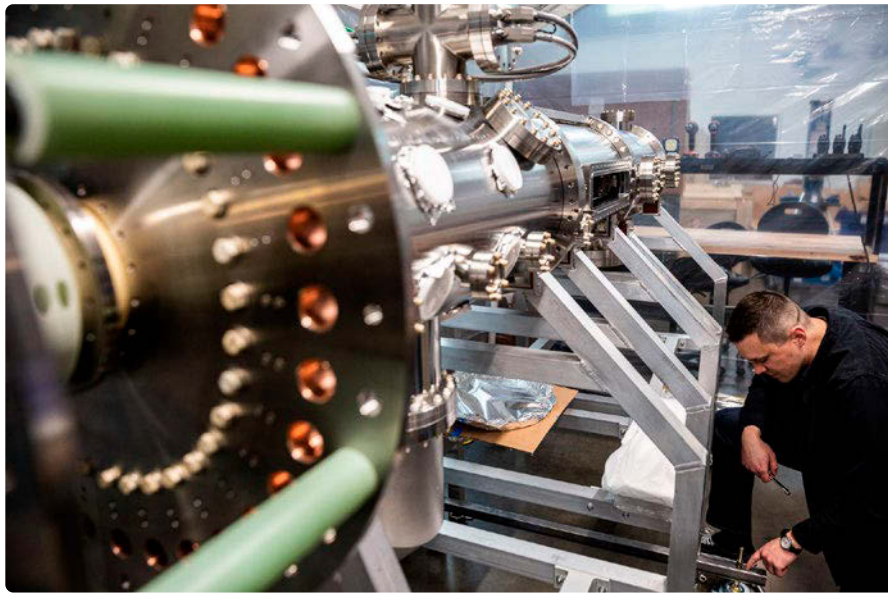
Zap Energy strives for magnetic confinement fusion power—with no magnets

Zap Energy has created the first plasmas in its FuZE-Q machine—the company's fourth prototype machine and the one it hopes will demonstrate a net energy gain from a Z-pinch fusion plasma just one millimeter in diameter and half a meter long. Zap Energy announced that engineering achievement and the close of $160 million in Series C funding in late June.

Z-pinch fusion features a thin line of plasma that carries an electrical current to generate its own magnetic field and "pinch" the plasma, compressing and heating it to the point that fusion can occur. Like other magnetic confinement fusion approaches, Z-pinch fusion strives for containment and must control plasma instabilities that can erupt within nanoseconds.

Zap Energy is building on a long history of Z-pinch fusion experiments around the world and approaching useful energy production by using sheared-flow stabilization (SFS) to suppress instabilities and sustain a plasma. SFS works by applying variable current to produce an axial plasma flow that varies by radius, with faster velocities farther from the center of the plasma column. The concept doesn't require magnetic coils or external heating systems—just the source to drive the electrical current. The conceptual basis for the technology was developed at the University of Washington with collaborators from Lawrence Livermore National Laboratory before it was spun out as a private company in 2017.

"Z-pinch has long been an appealing way to achieve nuclear fusion, but for many years researchers considered Z-pinch's plasma instabilities to be an insurmountable challenge," says Uri Shumlak, Zap Energy's chief science officer and a University of Washington professor of aeronautics and astronautics. "We've shown through both simulation and experiment that sheared flows can stabilize fusion plasmas, and that the stability should extend to a commercially viable scale. The Zap Energy team has made rapid progress since this technology moved out of the lab, especially with recent team and investment growth."



The first plasmas created in FuZE-Q, shown here during assembly, represent a key step toward fusion experiments with net energy output. (Photo: Zap Energy)

The first plasmas in FuZE-Q follow work to extend the lifetime of stabilized plasmas achieved in its predecessor, FuZE—a machine that could supply up to 500 kiloamps (kA) of current. FuZE-Q, with a new power bank being installed later this year, is expected to be able to deliver over 650 kA of current—the current that models predict will be required to achieve a net energy gain, or Q=1.

"FuZE-Q is the fourth generation of Z-pinch device that we've built and is undoubtedly the most ambitious," notes Brian Nelson, Zap Energy's chief technology officer and a research professor emeritus at University of Washington. "We designed it to be versatile, resilient, and tunable in lots of ways that will be critical as we ramp to higher currents, temperatures, and densities."

Zap Energy's fusion power concept would inject deuterium-tritium gas to form a plasma that accelerates down a coaxial accelerator before assembling into a single Z-pinch plasma column on the axis. Fusion neutrons produced in the Z-pinch would be

Research & Applications continues

captured in a liquid lithium-lead blanket, which serves as return electrode, heat-transfer fluid, tritium breeding ground, and a biological shield.

Zap Energy sees potential for factory-built modular power plants that could support multiple fusion cores, each rated at about 50 MWe. At the annual ARPA-E Fusion Review Meeting in April, the company described its plan for cylindrical modules 3 meters in height and diameter and capable of producing about 200 MWt from 10-Hz pulsed operation.

U.K. fusion energy projects get regulatory clarity to speed deployment

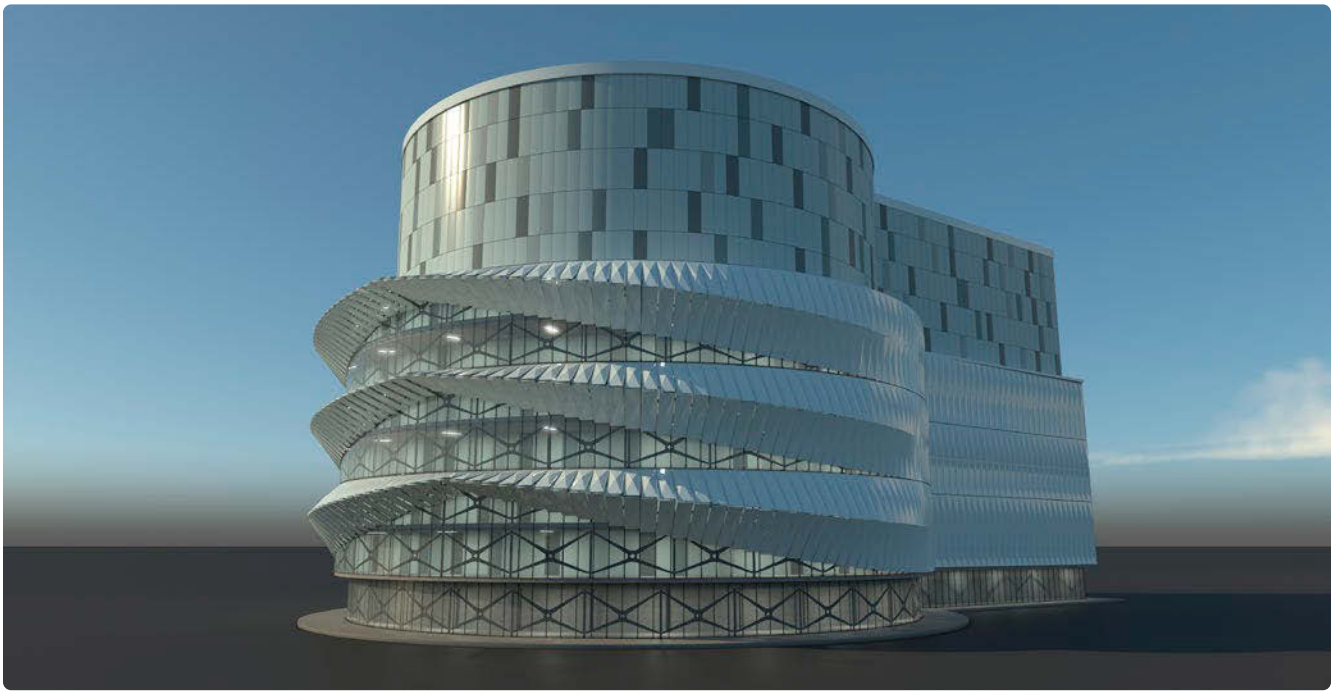
Future fusion energy facilities will continue to be regulated by the Environment Agency (EA) and Health & Safety Executive (HSE), the U.K. government announced June 20, and existing law on nuclear regulations will be amended to exclude fusion energy facilities from nuclear fission regulatory and licensing requirements. The move was announced by the United Kingdom Atomic Energy Authority (UKAEA) with the expectation it would provide "clarity to developers of prototype/demonstration fusion facilities currently being planned to support rapid commercialization."

The U.K. government decision is backed by a report titled *Towards fusion energy: The UK Government's response to the consultation on its proposals for a regulatory framework for fusion energy*, prepared by the Department for Business, Energy & Industrial Strategy.

Key decisions include:

- Current U.K. regulators of fusion R&D facilities will retain responsibility for fusion, and future fusion facilities will continue to be regulated by the EA and HSE (or devolved bodies as appropriate).
- This regulatory approach will apply to all planned fusion prototype energy facilities in the U.K., providing clarity to fusion developers aiming toward rapid commercialization.
- The government will legislate to make clear in law the regulatory treatment of fusion energy. This provides certainty and confidence to the industry by amending the law to exclude fusion energy facilities from nuclear regulatory and licensing requirements.

Ian Chapman, UKAEA chief executive, said, "This early confirmation of a



The Spherical Tokamak for Energy Production (STEP), shown here, is a government-backed prototype fusion energy plant planned for operation in the U.K. in the early 2040s. (Image: UKAEA)

proportionate regulatory framework will help accelerate the progress of fusion energy, which has great potential to deliver safe, sustainable, low-carbon energy for generations to come. It demonstrates our government's high-level support and progressive approach to enabling fusion to happen here in the U.K."

The government opened a consultation to seek views from stakeholders in October 2021 after publishing a green paper on its proposals for fusion regulation. Fifty-eight organizations responded, including regulatory bodies, fusion companies, research organizations, engineering firms, academicians, and members of the public. The June 20 announcement and report represent the government's response to the consultation.

While the U.K. is not unique in anticipating that fusion energy will require its own regulatory framework, it is ahead of the game at a time when private investment in fusion is soaring. In the United States, which has more private fusion companies than any other country, Nuclear Regulatory Commission staff continue to deliberate whether fusion should be regulated by the NRC in a similar way to a utilization facility, an accelerator facility, or with a new or hybrid approach.

Research & Applications continues

In Case You Missed It . . .

The IAEA wants to fight monkeypox and Lassa fever with a nuclear-derived technique previously used to combat COVID-19. In a June workshop on the sidelines of the International Atomic Energy Agency Board of Governors meeting, participants discussed how nuclear techniques backed by the IAEA's Zoonotic Disease Integrated Action (ZODIAC) initiative could assist countries in using nuclear and related techniques to detect, mitigate, and understand current outbreaks of the monkeypox and Lassa fever viruses. A system for screening for the virus in domestic and wildlife environments—similar to RT–PCR diagnostic systems already developed for COVID-19—is urgently needed, according to the IAEA.

IAEA director general Rafael Mariano Grossi addresses workshop attendees. (Photo: IAEA)

The first production of lutetium-177 in an operating power reactor was announced June 21 by an international collaboration of Bruce Power, Isogen (a joint venture of Kinectrics and Framatome), and ITM Isotope Technologies Munich SE. The Lu-177 was produced using an isotope production system (IPS) that was recently installed in Unit 7 of Bruce Power's CANDU nuclear power plant in Ontario. As part of the commissioning of the system, ytterbium-176 targets were irradiated to produce Lu-177 and then sent to ITM in Germany for processing. Lutetium-177 is a short-lived medical radioisotope that has been developed as a targeted therapy to treat a growing number of cancers.

The new IPS installed in Bruce Power's Unit 7 will produce Lu-177 for treating cancer. (Photo: Bruce Power)

An occupational exposure database for industrial workers exposed to NORM—naturally occurring radioactive material—was launched in June by the International Atomic Energy Agency as part of the Information System on Occupational Exposure in Medicine, Industry, and Research (ISEMIR). More than 24 million workers around the world are engaged in industrial processes involving NORM, including mining, oil and gas production, mineral sands, water treatment, metal refining and recycling, phosphate production, and geothermal energy, according to the IAEA. The new database, ISEMIR-N, joined two existing databases of the ISEMIR system: ISEMIR-IC, for workers in interventional cardiology, and ISEMIR-IR, for workers in industrial radiography.

A worker at a coal mine site in Poland. (Photo: IAEA)

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

Orano's DN-30 transport package can carry 30B cylinders of enriched UF_6. (Photo: Orano)

NATIONAL LABS

Orano, TerraPower get vouchers to study LEU+ transport and chlorine chemistry

The Gateway for Accelerated Innovation in Nuclear (GAIN) awarded vouchers to Orano Federal Services and TerraPower on June 22, giving them access to specialized facilities and expertise at Department of Energy national laboratories in exchange for a minimum 20 percent cost share. Orano is partnering with Oak Ridge National Laboratory on a new technical study that updates the physical chemistry limits for the safe transport of uranium hexafluoride (UF_6) gas enriched up to 10 percent in existing shipping containers, and TerraPower is turning to Los Alamos National Laboratory's neutron testing capabilities to measure the properties of chlorine isotopes and determine how they will behave in the Molten Chloride Reactor Experiment (MCRE).

Previous studies to establish UF_6 limits in shipping containers covered enrichments up to 5 percent. According to GAIN, Orano's project "will review the available literature and update these studies with current techniques, evaluate the impact of higher enrichments in safety criticality cases in transport conditions, and publish a report that will serve as the basis to the safety criticality analysis that will be provided for review and approval to the radioactive material transport regulators, for the DN-30 package with 30B cylinders containing enrichment higher than 5 percent."

Orano will carry out the work in cooperation with the Nuclear Energy and Fuel Cycle Division at ORNL, which has the facilities and staff to establish realistic physical and chemical configurations for the 30B cylinder with water flooding. The new study will be used for review and approval by radioactive material transport regulators, according to GAIN.

With UF_6 shipping containers approved for higher enrichment limits, a Category III enrichment facility (authorized to enrich uranium up to 10 percent U-235) could produce and ship UF_6 enriched to between 5

and 10 percent U-235, a category that has informally been labeled LEU+. LEU+ falls between the low-enriched uranium used in operating light water reactors (typically enriched to between 3 and 5 percent U-235), and high-assay low-enriched uranium (HALEU, enriched to between 10 and 20 percent U-235). LEU+ could potentially be shipped from a Category III enrichment facility to a Category II facility for enrichment to the HALEU levels required by many advanced reactor designs.

TerraPower is developing the Molten Chloride Fast Reactor and MCRE in cooperation with Southern Company and other partners. The design and operation of MCRE relies heavily on the quality of nuclear data, including data for chlorine-35 and chlorine-37 for many reactions, according to GAIN, and recent Cl-35 measurements "significantly disagree with evaluated nuclear data (ENDF/B-VIII.0) in the most important neutron energy range to the MCRE."

TerraPower will partner with the Los Alamos Neutron Science Center at LANL to produce high-quality measurements of Cl-35 and Cl-37 cross sections and reevaluate chlorine nuclear data libraries to reduce regulatory uncertainty for chloride salt reactors.

INL's Advanced Test Reactor prepares to irradiate thorium-HALEU fuel pellets

The Advanced Test Reactor (ATR) at Idaho National Laboratory will soon be irradiating fuel pellets containing thorium and high-assay low-enriched uranium (HALEU) developed by Clean Core Thorium Energy for use in pressurized heavy water reactors (PHWRs). Clean Core announced on June 14 that it will proceed with irradiation testing and qualification under an agreement with the Department of Energy; the plans have been in the works since at least 2020, when the DOE filed a National Environmental Policy Act (NEPA) disclosure for the work.

Clean Core expects its fuel, dubbed ANEEL (advanced nuclear energy for enriched life), to decrease the operating costs of CANDU reactors and other PHWRs while reducing the volume of high-level waste generated. The pellets destined for testing in the ATR have been fabricated at Texas A&M University under INL's quality assurance requirements and are ready for insertion in a testing assembly. INL expects to begin irradiating the fuel by the end of 2022 or early 2023.

While fuel testing proceeds at INL, Clean Core plans to complete performance and safety assessments and a demonstration irradiation of full-size fuel assemblies in a CANDU reactor with partners in Canada to support a goal of having ANEEL fuel assemblies installed in CANDU reactors by the end of 2025.

(Photo: Clean Core Thorium Energy)

In early 2021, Clean Core and Centrus Energy signed a memorandum of understanding to promote the use of ANEEL advanced nuclear fuel in PHWRs. While the initial test pellets being fabricated by

Research & Applications continues

Texas A&M use a small quantity of HALEU supplied by INL, Clean Core plans to use HALEU from Centrus for commercial-scale production of ANEEL fuel.

According to a NEPA determination prepared by INL and approved in September 2020, thorium is about three times more abundant in nature, compared with uranium, and occurs mainly as the "fertile" thorium-232 isotope capable of breeding fissionable uranium-233. Thorium fuels were used in experimental and prototype reactors from the 1950s through the mid-1970s. "There is a renewed interest in thorium-based fuels because of its intrinsic proliferation resistance due to the presence of U-232 and its strong gamma-emitting daughter products; its better thermo-physical properties and chemical stability relative to UO_2, which ensures better in-pile performance and a more stable waste form; and its irradiated fuel contains far less long-lived minor actinides than do fuels in the traditional uranium fuel cycle," the document reads.

The NEPA determination indicates that the fuel will use HALEU with an initial U-235 enrichment less than or equal to 16 weight percent. "Final rodlet fabrication will be performed by the INL," the determination states. "After the fuel burnup objectives are met in ATR, samples will be transported to [the Materials and Fuels Complex] and post-irradiation examinations will be performed at the Hot Fuel Examination Facility."

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The Palisades nuclear power plant. (Photo: Holtec International)

Holtec acquires Michigan's Palisades and Big Rock Point

Holtec International has announced that it has completed the acquisition of the Palisades nuclear power plant and the Big Rock Point site from Entergy Corporation. The Nuclear Regulatory Commission approved the license transfer for the two sites, both located in Michigan, in December 2021.

Under Holtec's asset transfer agreement with Entergy that was announced on June 28, ownership of the sites has been transferred to Holtec International, with Holtec Decommissioning International serving as the license holder and prime decommissioning contractor.

Located in Covert, Mich., Palisades' 777-MWe pressurized water reactor was removed from service on May 20 after more than 50 years of operation. The shutdown occurred 11 days prior to the plant's scheduled May 31 retirement date after a site and world-record production run of 577 straight days of operation. Big Rock Point, located in Charlevoix, Mich., was shut down in 1997 and decommissioned in the early 2000s. Only the reactor's independent spent fuel storage installation remains at the site.

According to Holtec, construction of the company's SMR-160 small modular reactor at Big Rock Point and Palisades are among the viable options for repurposing the sites. The first Holtec SMR-160s are scheduled to enter service around 2030.

Holtec has stated that over the past few years it has been working methodically with Palisades personnel on an integrated transition plan, laying the foundation for decommissioning of the site. The first substantial activity will be moving the plant's spent fuel from its spent fuel pool to dry storage, which is projected to be completed by 2025.

The company added that the balance of the dismantling and decommissioning operations will be aligned to take advantage of Holtec's implemented fleet model, called the Holtec Management Model, which is informed by the ongoing work at other Holtec-owned decommissioning sites, including the Oyster Creek, Pilgrim, and Indian Point sites.

The Palisades decommissioning project will have a 19-year timeline and will render the 400-plus acre site fit for commercial and industrial use, except for the independent spent fuel storage installation.

HANFORD SITE

Supreme Court rules against Washington workers' comp law

The U.S. Supreme Court has struck down a Washington state workers' compensation law that was designed to make it easier for workers at the Department of Energy's Hanford Site to receive compensation benefits. The court, by unanimous decision, found on June 21 that the law violates the U.S. Supremacy Clause and discriminates against the federal government and its contractors.

In 2018, Washington state lawmakers passed legislation amending the workers' compensation law to presume that diseases, including cancers and respiratory illnesses, that developed while employed at Hanford are occupational and should trigger benefits eligibility. The 2018 law applied exclusively to workers at the DOE's Hanford Site, located near Richland, Wash.

The federal government challenged the law, arguing that it exposes government contractors, and by extension the United States, to high costs that are not incurred by similarly situated state and private employers. The law was upheld by the U.S. District Court for the Eastern District of Washington in 2019, and the Ninth Circuit Court of Appeals affirmed that decision in August 2020. The Biden administration then appealed the case to the Supreme Court in September 2021.

After the Supreme Court agreed to hear the case, and to address concerns voiced by the federal government, the Washington state legislature modified the law in March of this year to apply to all workers at all radiological waste sites in the state. Having amended the law, Washington argued that the case was moot and should be dismissed by the Supreme Court.

In delivering the Supreme Court's opinion, Justice Stephen Breyer said that the Washington state law is unconstitutional under the Supremacy Clause, which "generally immunizes the federal government from state laws that directly regulate or discriminate against it." Breyer further added that the law does not fall under a congressionally mandated waiver of immunity.

An aerial view of Hanford's Waste Treatment and Immobilization Plant in 2021. (Photo: Bechtel National)

As for the state's argument of mootness, Breyer said, "If there is money at stake, the case is not moot." Breyer noted that, in winning the case, the U.S. government stands to recoup or avoid paying between $17 million and $37 million in workers' compensation claims awarded under the 2018 law.

Following the Supreme Court's decision, Bob Ferguson, attorney general for the state of Washington, said that the court's ruling does not affect the state's amended 2022 law, which will remain in place.

"Because the legislature already fixed the issues the federal government raised, there is little practical impact in Washington as a result of this ruling," Ferguson said. "Hanford workers, and all others working with dangerous radioactive waste, remain protected. The federal government has not challenged this new law. If they do, we will defend these protections all the way back up to the Supreme Court again if we have to."

Waste Management continues

Waste Management

Cocooning begins on K East Reactor

The Department of Energy's Office of Environmental Management (EM) reports that construction is well underway on a protective enclosure, or cocoon, for the K East Reactor building at the Hanford Site near Richland, Wash. EM states that it has achieved one of its key construction priorities for 2022 by beginning construction of the enclosure, which is designed to protect the reactor building while the radioactivity in the deactivated reactor core decays over the next several decades, making it safer and easier to decommission.

The first steel columns, each weighing up to 28 tons, were placed for a cocoon over the former K East Reactor building at the Hanford Site. (Photo: DOE-EM)

Last summer, EM contractor Central Plateau Cleanup Company was awarded a subcontract for the installation of the steel frame, and crews broke ground on the site last fall. Earlier this year, workers finished backfilling and compacting the area around the former reactor with approximately 34,000 cubic yards of sand and gravel to level the site before pouring a 6-foot-thick concrete foundation to support construction of the cocoon. The first steel columns for the enclosure were placed in mid-May.

Construction activities will continue

In Case You Missed It . . .

Canada's Nuclear Waste Management Organization has announced that it has successfully completed a full-scale demonstration of the engineered barriers that are designed to contain and isolate Canada's spent nuclear fuel in a deep geological repository.

A modified forklift with a customized handling attachment is used to move spent fuel containers and their heavy bentonite clay housings. (Photo: NWMO)

Responsible for the long-term management of Canada's spent nuclear fuel, the NWMO said the demonstration was the culmination of more than eight years of preparation, including the design and fabrication of specialized prototype equipment and components by the organization's technical specialists and engineering partners.

"All elements of the demonstration performed as expected and according to plan," said Chris Boyle, vice president and chief engineer at the NWMO. "The demonstration shows not only the NWMO's ability to install the engineered-barrier system, but also the caliber of our technical teams, who are invested in the project's success and committed to doing what's right for Canadians and Indigenous peoples."

The nuclear waste management market is expected to reach a value of nearly $7 billion by 2027, according to a new research report published by Market Research Future. This value would represent a compound annual growth rate of 2.8 percent between 2021 and 2027.

The driving force behind the market growth is an increased awareness of the importance of nuclear waste management, according to a *GlobeNewswire* release on the MRFR report, which adds that the waste market value has been impacted positively by three factors: stringent regulations to control nuclear power plant emissions, introduction of advanced technologies, and increased funding for waste management facilities from both the public and private sectors.

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

through the summer, with workers expected to finish the structural steel skeleton and install metal siding on the walls and roof to fully enclose the building by this fall. The completed structure will be more than 150 feet wide and 120 feet tall. The design allows for routine inspections of the reactor every five years. Additional safety features include new lighting between the structure and the reactor building, as well as upgraded lighting inside the building.

The K East Reactor operated from 1955 to 1971 and will be the seventh of Hanford's nine former plutonium production reactors to be placed in interim safe storage. The K West Reactor will be the eighth. The ninth, the B Reactor, has been preserved as the world's first full-scale plutonium production reactor and is part of the National Park Service's Manhattan Project National Historical Park. Hanford's other six reactors were cocooned between 1998 and 2012.

NORWAY

Jacobs, Multiconsult to plan nuclear decommissioning program

A joint venture of Jacobs and Oslo-based engineering company Multiconsult Norge have been selected by Norsk Nukleær Dekommisjonering (NDD) to plan the decommissioning of Norway's nuclear facilities. NDD is the state-run enterprise responsible for the decommissioning of Norway's nuclear facilities and radioactive waste management.

The initial focus of the framework contract, which has an estimated value of up to

Waste Management continues

The JEEP-II facility at Kjeller, Norway. (Photo: Institute for Energy Technology)

$100 million (NOK 1 billion) over six years, will be on two research sites—the nuclear fuel and materials testing reactor at Halden and the JEEP-II neutron scattering facility at Kjeller—that were shut down in 2018 and 2019, respectively.

The Jacobs/Multiconsult joint venture was ranked the highest bidder for the NDD contract and will have first option to carry out the work, which includes engineering concept design and planning of new facilities, upgrading of existing nuclear and non-nuclear facilities, and supporting NDD with technical documentation, as well as preparing safety cases to meet ownership and operating license requirements.

The overall program for used fuel treatment and decommissioning of the Halden and Kjeller reactors is expected to cost about $1.96 billion (NOK 20 billion) and take 20–25 years. Decommissioning of the facilities includes removing radioactive sources, dismantling equipment and systems, demolishing structures and buildings, and transferring radioactive material to a facility approved for storage.

Karen Wiemelt, senior vice president of Jacobs Energy, Security, and Technology, said that the NDD contract will expand Jacobs's footprint in a European nuclear decommissioning market that is estimated to grow to $63 billion (€60 billion) by 2025.

"We are looking forward to carrying out this work to lay the foundations for a safe and effective cleanup that will protect people and the environment from the radioactive legacy on these two sites," Wiemelt said.

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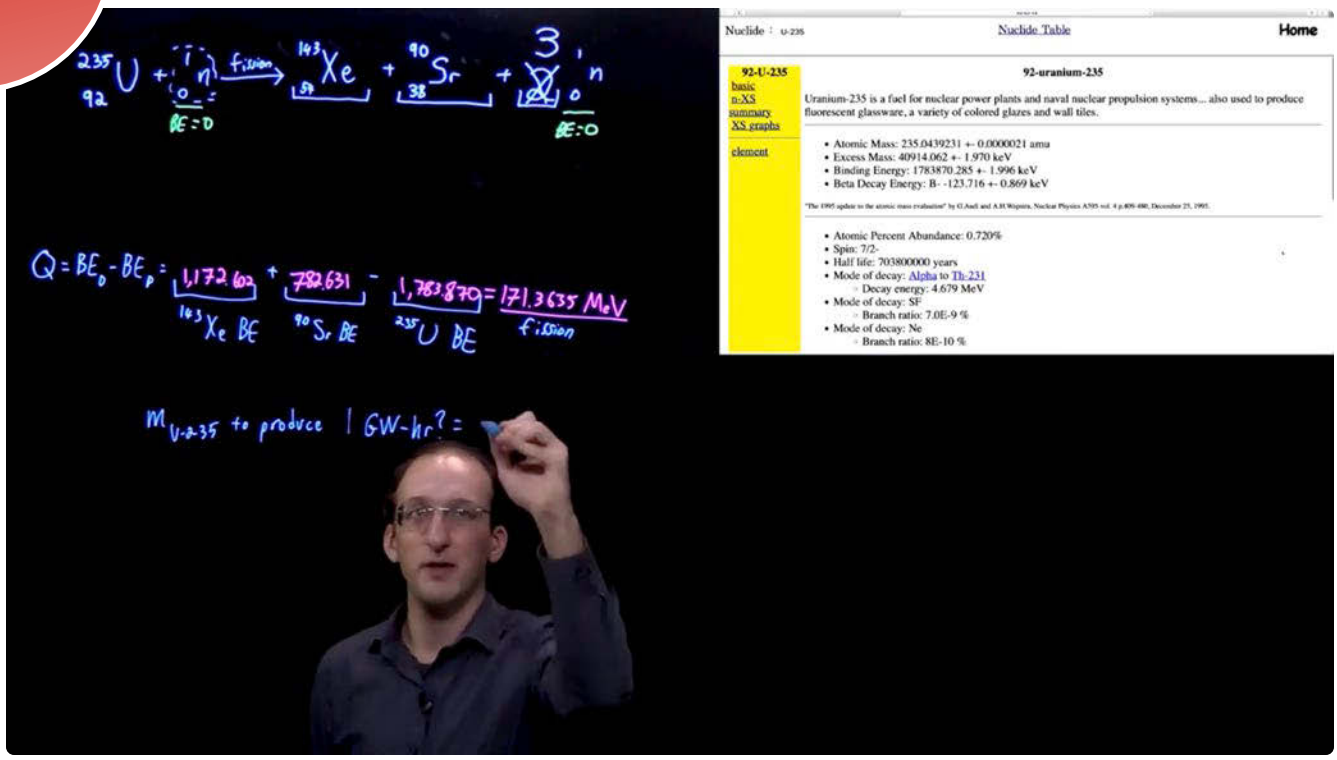


A still from the online course in which professor Mike Short explains how to calculate the Q value from a single nuclear fission reaction. (Image: MIT)

MIT's online nuclear energy course exceeds "wildest expectations" in enrollment

In 2019, the Massachusetts Institute of Technology launched a massive open online course (MOOC) titled "Nuclear Energy: Science, Systems and Society," available to any interested person in the world with virtually no limit on access or attendance. Now in its fourth offering, the course has had enrollment results that have "exceeded our wildest expectations," notes Jacopo Buongiorno, an MIT nuclear engineering professor and one of the developers of the MOOC. According to Buongiorno, who is also director of the MIT Center for Advanced Nuclear Energy Systems (CANES) and science and technology director at the MIT Nuclear Reactor Laboratory, "Over 12,000 students have signed up for the course over the past four years. To put this number in perspective, a typical nuclear science and engineering class at MIT will get 10 to 30 students per semester."

He continues, "We have also had a geographically diverse population of students, with large numbers from the United States, India, China, Europe, and Brazil, as well as many other countries. And there's a wide distribution of backgrounds and education, from high school to [doctorates]."

The course at a glance

"Nuclear Energy: Science, Systems and Society" is one of several extracurricular nuclear-related courses that MIT has long made available during the summer months. This 14-week-long introductory course, offered via the edX platform, focuses on the peaceful uses of nuclear power and radiation. It is self-paced, requiring about eight to 10 hours of study per week. Though familiarity with high-school-level calculus can be helpful, it is not a requirement. Enrollment is free of charge, but participants may choose a $75 upgrade to receive a formal certificate upon completion.

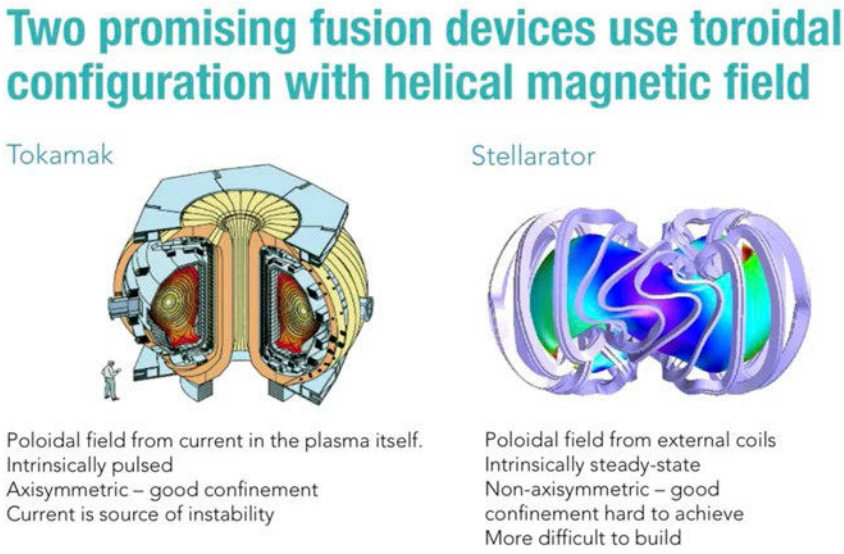
Students in the course learn the basic physical principles of nuclear energy and radiation, including the benefits of nuclear power as a reliable, safe, carbon-free, affordable energy source and the value of radiation in nuclear medicine, scientific research, quantum technology, and security-related activities. It covers the scientific, engineering, and economic aspects of current fission reactors, as well as the latest research in advanced nuclear reactor technology. Research in magnetic fusion energy is also explored, including the scientific and engineering basis of tokamaks, MIT's work with high-magnetic-field fusion reactors, and other fusion experiments being conducted around the world.

An optional part of the course gives students the opportunity to follow guided, hands-on, online exercises and experiments to delve deeper into the subject matter, such as measuring background radiation levels. Students can use a Geiger counter to determine the amount of radiation in their home, backyard, workplace, or any other site they might be interested in exploring.

Real-world questions—with real answers

The broad appeal of this popular online course may be related to the real-world questions and concerns it addresses. Students move beyond the common notion of nuclear energy as a complicated, potentially dangerous technology and examine the many interesting aspects of the subject and the science. Among the issues that participants will be able to critically assess for themselves after the course are the following:

- Sources, both common and uncommon, of radiation.
- Nuclear energy's role in solving the climate change problem.
- Cost competitiveness.
- Concern about proximity of nuclear power plants to populated areas.
- The basics of fusion energy and the viability of proposed paths to develop fusion reactors.
- Levels of background radiation in daily life.
- The challenges and opportunities in quantum computation and quantum technology.



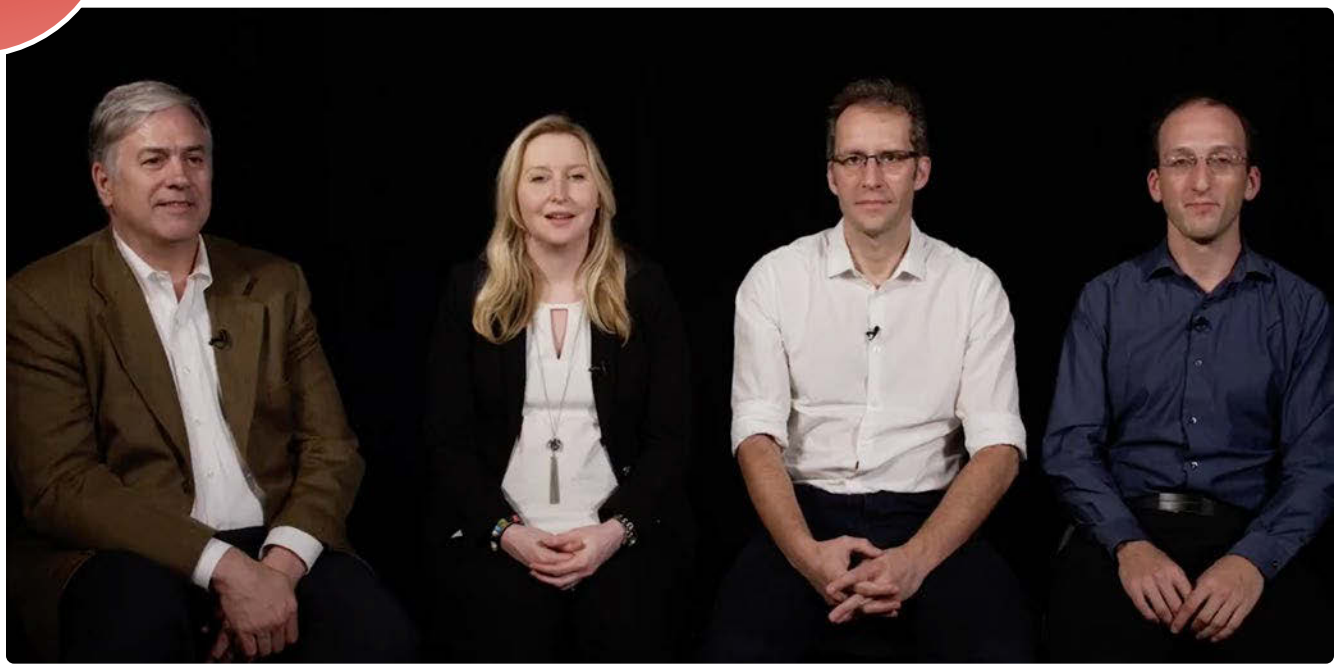
A still from a course video on magnetically confined nuclear fusion. (Image: MIT)

From the basics to the cutting edge

The scope of the nuclear energy MOOC also makes it an exciting prospect for those eager to learn. The syllabus is divided into four modules, progressing from basic concepts to current applications to cutting-edge research and advanced applications, making it accessible to all students, even those with a beginner's knowledge of the subject matter.

In the first module, the basic facts about ionizing radiation are introduced, including the origins, energetic properties, and useful applications of ionizing radiation. Attributes and challenges of nuclear energy as a source of electric power are the focus of the second module, where students learn about the role that nuclear energy plays in decarbonizing the energy sector and mitigating the effects of climate change, as well as the economic and business aspects and recent innovations in nuclear. The science of nuclear fusion is covered in the third module, including concepts of plasma physics involved in magnetic confinement in fusion reactors, current innovative research, and possible future directions of fusion. The fourth and final module covers the latest applications of nuclear science and nuclear engineering outside of the energy sector, such as the emerging fields of quantum science and quantum engineering.

Education continues



A still from the online course's introductory video, featuring some of its professors (from left): John Parsons, Anne White, Jacopo Buongiorno, and Mike Short. (Image: MIT)

Paola Cappellaro (Photo: MIT)

Powerful pedagogy

It's not every day that a person gets to experience a top-tier education—or have access to some of the finest scientific minds in the country—free of tuition, no less. The five accomplished MIT faculty members who developed the MOOC and serve as instructors have been drivers of enrollment. Professor Buongiorno serves as the course's point of contact on behalf of the faculty. The other instructors are Anne White, engineering professor; Michael Short, associate professor of nuclear science and engineering; Paola Cappellaro, professor of physics and nuclear science and engineering; and John Parsons, a senior lecturer at the MIT Sloan School of Management.

The unique expertise that each instructor brings to his or her lectures contributes to the well-roundedness of the MOOC. This powerful pedagogy has also undoubtedly contributed to the positive experience of the students. Buongiorno notes, "We have received positive feedback about the value of the course from many students who took it. For most, this was their first introduction to nuclear science and technology, and they found the course both interesting and informative."

A model for other schools

Buongiorno and his fellow instructors are pleased by the strong and ongoing interest in "Nuclear Energy: Science, Systems and Society" and its impact on people worldwide. One disappointment, however, is that the licenses granted to edX by the U.S. Office of Foreign Assets Control are not broad enough to allow them to offer the course to learners in every location around the globe. Currently, U.S. government sanctions prevent the access to the course in certain regions, including Iran, Cuba, and the disputed Crimean Peninsula.

Nevertheless, the nuclear energy MOOC has become a key part of the education activities of MIT's Department of Nuclear Science and Engineering. The success of the course suggests that it could serve as a model for other institutions of higher learning. Buongiorno explains, "The MOOC is an important element of our department's mission to inform the public about the use of nuclear science and technology in addressing serious challenges facing humankind. The overwhelming response we have received suggests that there is a strong appetite for science-based input from trusted institutions like MIT."

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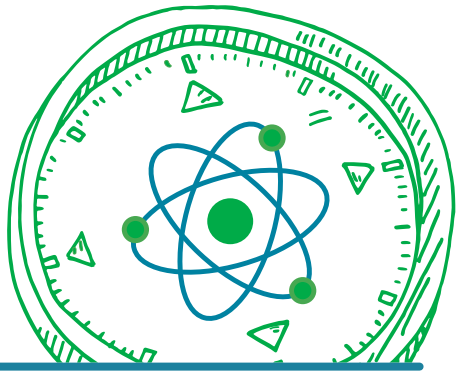

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The More Hall Annex photographed in 2009. Note the glass windows encompassing the building to allow passers-by to see the work of researchers inside. The abundant use of unfinished concrete and protruding aspects of the building are hallmark aesthetics of brutalist architecture. (Photo: Jon Mabel)

The More Hall Annex: Defining nuclear's place in society via architecture

By Mike Walker

The atomic age following World War II and the Cold War were catalysts for both unprecedented scientific progress and extraordinary imperatives toward the development and use of new technologies—many based around nuclear power. The impact of nuclear weapons was clear, but the promise of nuclear for peaceful, civilian applications became one without boundaries: not only were nuclear-generated electricity and the powering of naval vessels via nuclear reactors implemented, but nuclear-powered aircraft, spacecraft, and, incredibly, automobiles were under serious consideration and planning by the 1960s.[1]

Overall design and aesthetics including those for consumer applications took a strong lead from nuclear technology and the space age, with constant reminders of these technological advancements present in American society.[2] Yet beneath the rosy glow of populuxe, doo-wop interior design, and Googie architecture of the 1950s was the looming specter of the Cold War, and this also was present in architecture. Technological progress was hailed as a great American triumph, and military leaders who guided the Cold War technological push such as Hyman Rickover, Bernard Schriever, and Curtis LeMay became household names, featured on the covers of *Time* and other popular magazines.* Often, these men were seen as the architects and guardians of new technologies building a wall of defense between the United States and our Soviet adversary with their technologies as the primary means for keeping America safe.

*This is an important indicator of the time and social condition. While the popular press in more recent decades has still covered military technological advances, we did not see, for example, Air Force lieutenant general Leslie Keene on the cover of *Time* for her guiding of the F-35 program. Also, of course, there is the aspect that Rickover and to a slightly lesser degree LeMay were larger-than-life characters who virtually founded and ran their respective programs in an almost kinglike manner.

The actual architecture of nuclear facilities, of the *places of operation* necessary for the military and the Atomic Energy Commission (later, for the Department of Energy, as well), plus those for civilian power generation and research purposes, would take a turn toward embracing the concrete brutalism of the 1950s—a now rather maligned international architectural style that, if anything, was very appropriate for the pragmatic needs of nuclear engineering. Sturdy, safe concrete was the logical approach to securing nuclear reactors and associated facilities, but the *design* that went into many such facilities also really showcased American optimism, confidence in national security, and the concept of nuclear technology as a bulwark against the Soviet menace. However, on the flip side, with the Atoms for Peace initiative we saw a movement of reactors into research service at leading universities, where they represented not only the known beneficial applications of nuclear power of the time but investigation into the future for such applications. Of course, for such reactors, facilities were required, and many would be in prominent locations on college campuses—providing an architectural opportunity to showcase the peaceful, educational, and hope-fueled future of nuclear.

This article looks especially at one such facility, the Nuclear Reactor Building—commonly known as the More Hall Annex—that was at the University of Washington in Seattle. While there are many other notable university (and other) research reactor buildings, the More Hall Annex is intriguing for how a confluence of factors led to its unique and robust architectural design—a design so engaging that preservation groups vigorously battled to save the building when the university wished to raze it in favor of a new computer sciences facility. (Eventually the university won out, and today the building is no more.[3])

When the University of Washington received a grant from the Atomic Energy Commission in the late 1950s to purchase a research and training reactor for its newly formed nuclear engineering program, a structure to house the reactor—which would be an Argonaut-class research reactor—was necessitated. The chairman of the school's Department of Nuclear Engineering, Dr. Albert Babb, realized the historic gravitas of this reactor: it would be one of the first permanent research reactors at an American university, and he wanted its building designed in such a way that the control room and reactor would be visible to passers-by—mainly students—so they could see atomic research being carried out for peaceful purposes. Babb enlisted University of Washington architecture faculty members Wendell Lovett, Gene Zema, and Daniel Streissguth to design the building. Under the name The Architect Artist Group, or TAAG, these architecture professors set about to design a structure that would meet the seemingly competing criteria of safely and securely protecting the reactor and its affiliated facilities while also making the same facilities observable from the street. The approach taken by TAAG and Babb ran contrary to what other universities installing research reactors were doing—for example, at the University of Florida, University of Wisconsin, and University of Maryland, where the reactors were encased in concrete and hidden from all possible view in normally nondescript, often even windowless, buildings.[4]

While such designs were commonly considered essential for safety, Babb determined that if the reactor was submerged in earth and accessed from its top, the soil would absorb any radiation that escaped the reactor vessel itself—which would be very minimal in the first place. His confidence in the reactor vessel's own surety echoed premises employed by Rickover's nuclear navy in the installation of reactors in submarines, where additional shielding was by necessity sparse. Indeed, Rickover and his men were among the first to commence complex studies of reactor shielding, and the U.S. Navy placing reactors in submarines combined with the U.S. Air Force's desire to utilize reactors in aircraft were prime impetus for effective shielding limited to the reactor vessel itself, which was economical in terms of space and materials.[5]

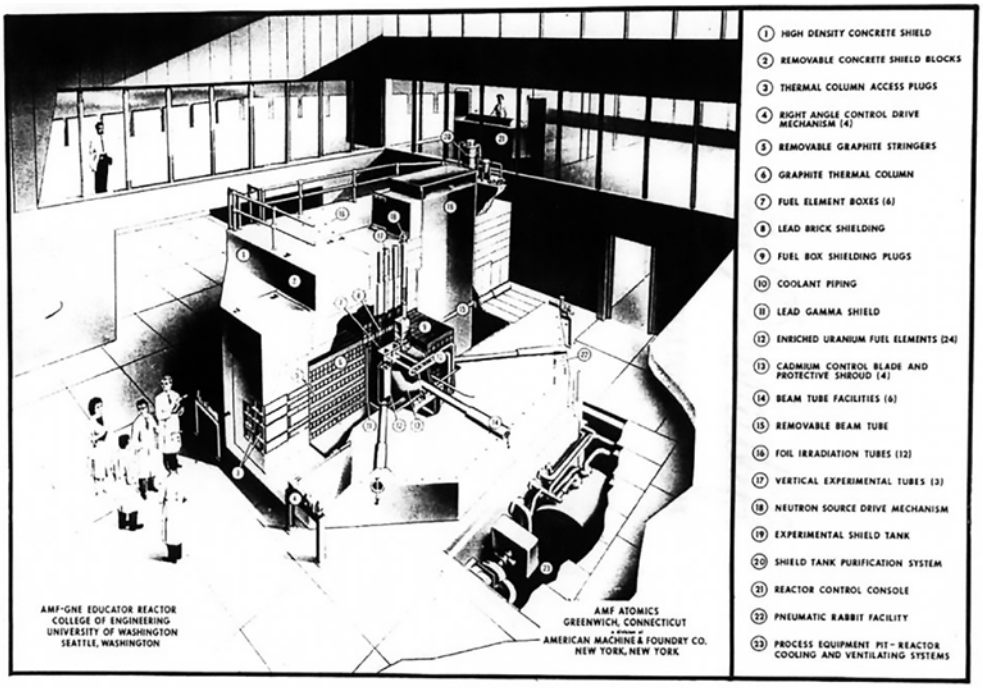
History continues

With assurances in hand for the safe feasibility of placing the reactor as Babb desired, Lovett and the other architects and their consulting engineer, Gerard Torrence, went about plans for the building to make it showcase not only the reactor and associated teaching and research spaces but the entire concept of nuclear power as a novel, integral aspect of engineering education.[6] In this building's architectural design, there was thus a clear imperative to indicate the arrival of nuclear as a major engineering discipline alongside established ones such as mechanical and electrical engineering and also to illustrate a commonality between the advancement of atomic research and the development of modern, brutalist architecture—both viewed as future waves of science-grounded progress.

Brutalism—so named for its use of exposed, unadorned concrete—came along at exactly the best time for the More Hall Annex project. Brutalist architecture was at the time becoming very popular for university campuses even when it did not supply notable structural advantages as it did with a building designed for nuclear research. "Brutalism" does not take its name from being brutal in any real regard but from the French term *béton brut*, or "raw concrete," plus the Swedish term of *nybrutalism*, or "new brutalism."[7] In both cases, it is the rawness and lack of any painting or decoration designed to camouflage the concrete nature of construction that defines this style of modernism as "brutal" and not any social or political agenda thereof. Despite this, brutalism has by no effort or intent of its own taken on various political connotations, from associations with Soviet communism via its extensive use in the Soviet Union[8] to negative connotations with postwar British efforts to address urban poverty through high-rise, brutalist housing projects.[9]

The TAAG architects, as faculty members of the University of Washington, were intimately familiar with the site of their building and how it should incorporate with the surrounding, extant architecture as well as with Babb's mandates for the structure. Externally, the structure needed to fit in with its site while also conveying that it was separate—a new, unique area of engineering, a new discipline of engineering as well as a new type of laboratory. On the inside, all the requisite apparatuses for nuclear science had to be accommodated, as well as inclusion of recent advances such as a pneumatic rabbit system for remotely accessing the reactor via tubing.[10] A "ring" format was utilized in the plan, allowing for engineers/students and outside observers alike to look down toward the reactor: those inside the building from a ground-level promenade and those outside via the large glass windows.

The abundant use of glass in the façade and overall small stature of the building in comparison with larger engineering and other academic buildings in its vicinity made the More Hall Annex seem welcoming—as intended—and offered no real clues as to its function. Indeed, the profusion of glass floor-to-ceiling windows might recall a high-street shop or restaurant or some sort of offices for student support: windows intone an open, welcoming sensibility while the low profile of the



TAAG diagram (circa 1960) of the reactor *in situ* and surrounding structure. (Image: from Ref. 4)

Photograph of the More Hall Annex, 2008. (Photo: Abby Martin)

building does not suggest a typical academic or laboratory facility.

In all these regards—the openness, the invitation to look in on nuclear work, the scale of the building fitting in quietly yet its design making it meant to stand out a bit—run solidly contrary to the thinking of the day about nuclear research reactor building architecture. This is not to suggest that other universities covertly squirreled their reactors away as secrets: the University of Florida, in example, has long had a large metal sign on the exterior of their own reactor building with an atom-inspired logo and the letters "UFTR" for "University of Florida Training Reactor."

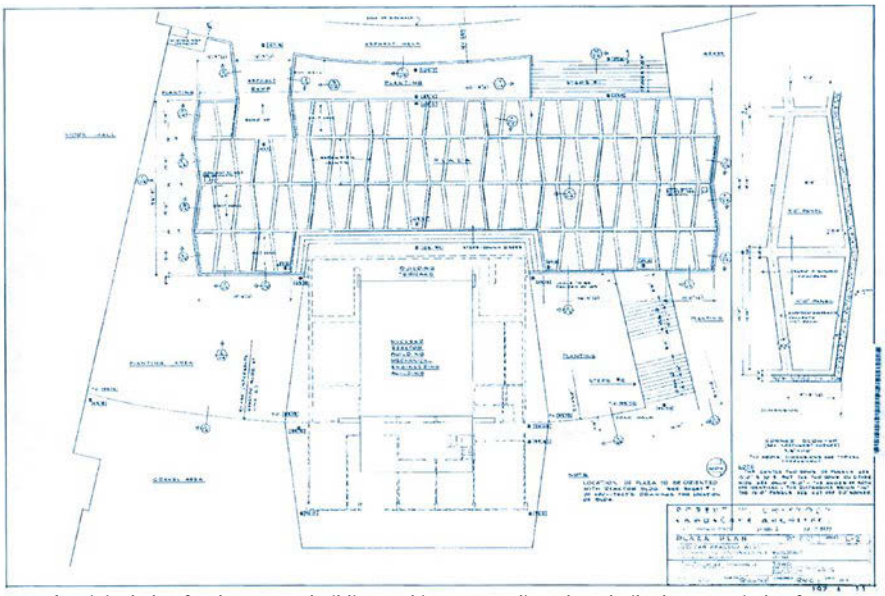
Still, the University of Washington building can be considered unique. In a time when expressions of both power and progress were promoted regarding nuclear energy, the More Hall Annex design brought forth both concepts but with the addition of inviting the public to participate in or at least view such progress. The choice of the architects

Signage on the University of Florida's training reactor (a TRIGA reactor) building at its Gainesville, Fla., campus. (Photo: University of Florida)

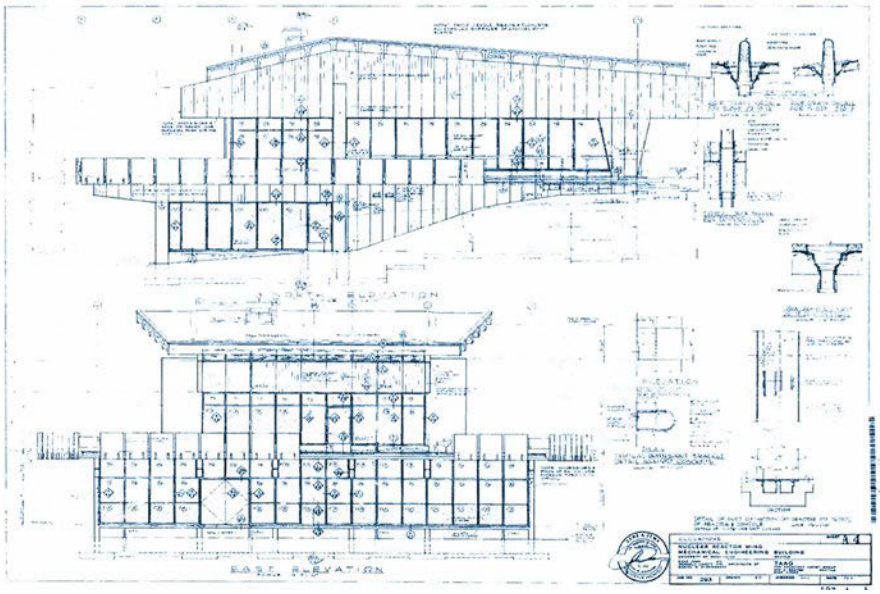
also is interesting: a firm composed of faculty architects from the very same university brought not only expert insight to the siting of the structure and the environment of the campus, but also a sense of deep

History continues

collaboration between nuclear engineering and architecture as disciplines and as sister faculties of the institution. This was a time of high atomic confidence, after all, and that is echoed throughout the design process. The architects explored new innovations in materials and craftsmanship of those materials, purposefully utilizing concrete to get away from the mundanity of the red brick buildings surrounding the More Hall Annex and offering jutting, ambitious uses of planes and angles echoing an exploratory, experimental mode of thought.



TAAG's original plan for the reactor building and its surrounding plaza, built almost entirely of concrete.



TAAG's original elevation-view schematic for the reactor building and its surrounding plaza.

While in many ways unique, the More Hall Annex shared its great nuclear optimism with many other facilities. It also was a swan song to brutalist architecture at a time when such architecture was far less maligned and considered to embody many of the same desirable aspects seen in nuclear power itself: pragmatism, economy, robust sturdiness, and surety. The More Hall Annex responded to a call for social participation and served as a massive public relations effort incarnate for nuclear power and education, but it also was a call to how *architecture* could stand upon the contributions of *engineering* much as nuclear engineering was asking society itself to trust further in the promises of the field.[11]

After decades of service and teaching scores of young students to be safe and effective reactor operators and cutting-edge scientists, the Department of Nuclear Engineering was closed down by the University of Washington in 1992. The main reason for disbanding the department at this time was a lack of interest in nuclear-based graduate studies: the department had seen a gradual decrease in both the number and quality of graduate students applying to study in the department, making it an expensive proposition to keep the faculty and facility up and running with such little educational output.[12]

The reactor itself had been taken off line in 1988. Between 2001 and 2016, the elaborate process of decommissioning the reactor and removing its control rods and other hazardous materials took place, with waste products taken for final disposal at the Hanford Site in Washington and the Integrated Waste Treatment Unit at Idaho National Laboratory.[13] A final destination for the reactor itself is not listed in any consulted Nuclear Regulatory Commission or University of Washington records; however, it

can be postulated it also likely went to Idaho.

Despite the "brutal" nature of the rough concrete, geometric angles, and streamlined form of the More Hall Annex plus its relatively small scale in contrast to surrounding buildings, its smooth edifice without decoration and lack of visible pipes or other services all spoke to the grace and economy of nuclear—signifying that nuclear was touted as a more environmentally friendly, economical, and sophisticated means of power generation than those such as coal that came before it. Nuclear was, after all, promised to propel spaceships to Mars, to revolutionize air travel, to provide the means to safeguard our seas via a nuclear navy.[14] While only the last of those goals was actually accomplished, the gravitas of nuclear research and its promise for broad solutions to key problems of modern society ranging from infinite energy to space travel to national security was seen as boundless at the onset of atomic age—and the More Hall Annex design was emblematic of it all.

Mike Walker (michaelwalker1@ufl.edu) is a journalist and a curatorial researcher at the Harn Museum of Art at the University of Florida. He holds a bachelor of fine arts degree in architectural history from the Savannah College of Art and Design and is completing a master of fine arts at the same institution.

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Get to know the board

The five newly elected members of the ANS Board of Directors began their terms at the end of the 2022 ANS Annual Meeting in Anaheim, Calif. The four U.S. members elected to three-year terms on the Board of Directors are Jamie Coble, of the University of Tennessee–Knoxville; Shaheen Dewji, of the Georgia Institute of Technology; Christina Leggett, of Booz Allen Hamilton; and Daniel Stout, of the Tennessee Valley Authority. Carlos Gho, vice president of Conuar S.A. (Argentine Nuclear Fuels), was elected to a two-year term as the non-U.S. member of the Board. Keep reading to learn more about the new directors.

Jamie B. Coble

The basics: An ANS member since 2002, Coble is an associate professor in the Department of Nuclear Engineering at the University of Tennessee–Knoxville.

Board goal: Coble said her main goal is to make sure ANS is an open, inviting, and accepting Society where everyone belongs and finds community. She plans to work with current and prospective ANS members to identify and dismantle barriers to belonging and community building.

Bet you didn't know: Coble was a member of a rock-climbing team that placed first in a local top rope competition—even though she is terrified of heights.

Shaheen A. Dewji

The basics: An ANS member since 2005, Dewji is an assistant professor in the Nuclear and Radiological Engineering and Medical Physics Programs at the George W. Woodruff School of Mechanical Engineering at the Georgia Institute of Technology.

Board goal: Dewji quoted Marie Curie: "You cannot hope to build a better world without improving the individuals. To that end, each of us must . . . share a general responsibility for all humanity." And in that spirit, Dewji said she would like to serve as an ambassador of ANS by encouraging all membership levels to help ANS be a resource to those external to the Society (i.e., the public, other professional societies, and industry stakeholders). In addition, she hopes to further engage the next generation of leaders of ANS while promoting diversity to create a mosaic of membership and expertise within the community.

Bet you didn't know: Dewji stays active in her free time by playing tennis and training for half marathons. It is her goal to one day complete an Ironman triathlon.

Christina J. Leggett

The basics: An ANS member since 2013, Leggett is a nuclear consultant at Booz Allen Hamilton and for the Department of Energy's Advanced Research Projects Agency–Energy.

Board goal: Public engagement is important to Leggett; therefore, she hopes to expand ANS's influence both domestically and abroad by increasing public awareness of the many beneficial applications of nuclear technology.

Bet you didn't know: Leggett unwinds with her hobbies of playing video games and trying new foods, and her technical interest (and expertise) is in reprocessing the nation's used nuclear fuel. "Let's just do it already," Leggett concluded.

Daniel P. Stout

The basics: An ANS member since 2009, Stout is the chief nuclear officer at Ultra Safe Nuclear Corporation.

Board goal: Stout believes ANS has an important role to play in helping inform policymakers to support the current and next generation of nuclear reactors. His goal is to amplify the voice of ANS to inform and influence nuclear energy policy.

Bet you didn't know: When Stout graduated college, then president Ronald Reagan handed him his diploma. Just a few months after graduating, he was working for Dr. Robert Ballard when Ballard discovered the *Titanic*.

Carlos Gho

The basics: An ANS member since 2022, Gho was recently appointed dean of the Graduate Program on Technological Applications of Nuclear Energy at the Instituto Balseiro after 49 years at the National Atomic Energy Commission of Argentina.

Board goal: As a member of the Latin American local section of ANS, Gho's goal is to help advance the mission of ANS in developing countries as those nations pursue nuclear power.

Bet you didn't know: Gho, who lives in San Carlos de Bariloche in Argentina's Patagonia region, enjoys being out in nature and frequently can be found hiking, mountain climbing, or skiing. He also loves traveling the world with his wife.

Returning to normal: The ANS Annual Meeting

The ANS Annual Meeting in Anaheim, Calif., was the first in-person Annual Meeting since 2019! It was clear, with nearly 1,000 people in attendance, that everyone was excited not only to listen to great speakers and hear the latest updates about all aspects of nuclear technology but to just be with one another, conversing in the hallways, and simply celebrating ANS and the technology we love and support.

This year's theme was "The New Outlook," as the nuclear community—and the world—emerges from the pandemic. That theme was appropriate as there is considerable optimism about the future of nuclear fission and fusion in spite of the challenges of the last two years.

Steve Nesbit, immediate past president of ANS, said, "The meeting was a very positive experience overall for me. There was so much excitement and events going on that kept me very busy, that the meeting went by quickly. I did my best to savor the experience of being back together as a professional community."

Nesbit applauded Per Peterson, chief nuclear officer of Kairos Power and the general chair of the meeting, for getting the meeting off to a great start during the opening plenary (more detailed coverage can be found on page 32 of this issue). Following the opening plenary, many attendees went outside for a photo op behind two banners depicting the nuclear community's support for Diablo Canyon. "Our demonstration of support for Diablo Canyon reinforced how ANS plays an important role in the broader

ANS News continues

Speeches at the first in-person ANS Annual Meeting since 2019.

NEW MEMBERS

The ANS members and student members listed below joined the Society in June 2022.

Abdallah, Mohamad, U.K. Atomic Energy Authority
Aboud, Eric
Adkins, Kenneth, Flour-BWXT Portsmouth
Apelian, Tsolag, Curtiss Wright
Arnold, Richard

Baez-Cazull, Susan
Bhattacharya, Arunodaya, Oak Ridge National Laboratory
Bistline, John, Electric Power Research Institute
Braithwaite, Lindsay, Nuclear Promise X
Branscum, Luke, U.S. Department of Energy
Breed, Chris, TerraPower
Breidokaite, Simona, Lithuanian Energy Institute (Lithuania)
Bristol, Jonathan, NuScale Power
Budner, Jeniece, Frontier Technology Corp.

Camargo, Manuel, Southern California Edison
Caplin, Grégory
Carr, Jon, U.K. Atomic Energy Authority
Castronova, Mark, Tennessee Valley Authority
Cholvy, Laurent, CEA Saclay (France)
Christensen, Boyd, Battelle Energy Alliance
Cilliers, Anthonie, Kairos Power
Collens, Thomas
Connelly, Samantha, Department of Homeland Security
Costa-Greger, Justin, Zap Energy
Crawford, Taylor, FeO

Damba, Darwin, U.S. Department of Energy
De Wet, Dane
Demoncheaux, Elise, Princeton Plasma Physics Laboratory
Doron, Oded, Kairos Power
Duluc, Matthieu, Institut de Radioprotection et de Sûreté Nucléaire (France)
Duncan, Robert, II, Tennessee Valley Authority

Favre, Luc, Électricité de France R&D (France)
Feuerle, Adrien, Andra (France)
Finley, Ed
Flippin, Nicole, Duke Energy/Robinson
Fu, Chun, General Atomics

Garcia-Diaz, Brenda, Savannah River National Laboratory
Gerding, William, BWXT Nuclear Operations
Gilbert, Mark, U.K. Atomic Energy Authority
Giles, Kaitlin, Southern Nuclear
Glenn Griesinger, Nancy, Texas Southern University
Granowski, Michael, Roland Berger LP
Grierson, Brian, General Atomics
Guerra, Jordan, Framatome
Guo, Zhexi

Hall, John, National Technology and Engineering Solutions of Sandia
Haney, Keith
Haroon, Jawad, Ontario Tech University (Canada)
Harshman, Frank Jr., Defense Nuclear Facilities Safety Board
Harvey, Mark, Texas Southern University
Hay, Stewart, Cerberus Nuclear (U.K.)
Heigh, Jeffrey
Herth, Johann, Institut de Radioprotection et de Sûreté Nucléaire (France)
Hiltz, Thomas, U.S. Department of Energy
Hirako, Yotaro, Sumitomo Corporation of Americas
Hitchcock, Dale, Savannah River National Laboratory
Ho sang, Yoon
Hoefer, Axel, Framatome GmbH (Germany)
Hu, Shenyang, Pacific Northwest National Laboratory
Humbert, Philippe, Commissariat à l'énergie atomique et aux énergies alternatives (France)
Hussain, Muhammad

Imamura, Michitaka, Nuclear Engineering Ltd. (Japan)
Izzo, Thomas, Core Synergy

Joyce, Mark
Juutilainen, Pauli, VTT Technical Research Centre of Finland

Kim, Gisub, Korea Institute of Radiological and Medical Sciences (South Korea)
Kim, Pyoungchung, TerraPower
Kim, Sangrok, Korea Institute of Radiological and Medical Sciences (South Korea)
Kim, Si Hwan, Users Co.
Kondo, Jun, Embassy of Japan
Kong, Tae Young, Chosun University (South Korea)
Konishi, Satoshi, Kyoto Fusioneering
Kramer, Justin, NuScale Power

Larsen, George, Savannah River National Laboratory
Lee, Jung-Kun, University of Pittsburgh
Lee, Katherine, Faraday Technology
Lewis, Ashley, Kairos Power
Lin, Zhihong, University of California–Irvine
Lonergan, William, Consolidated Nuclear Security
Lopez, Clement, Commissariat à l'énergie atomique et aux énergies alternatives (France)
Lopez Morales, Angelica, North Carolina State University
Lore, Jeremy, Oak Ridge National Laboratory
Lusardi, Michael, NuScale Power
Lybark, Jessica

Macpherson, Graham, Frazer-Nash Consultancy
Masten, Adam, Ultra Safe Nuclear Corp.
Mastrosimone, Nick
Matiienko, Oleh (Germany)
Miner, Ian, Commonwealth Fusion Systems
Mitchell, Lauren, Crane Nuclear PFT Corp.
Murphree, Kimberly, Southern Nuclear
Mutha, Heena, Commonwealth Fusion Systems

Nagao, Taka
Ni, Yelin, Pacific Northwest National Laboratory

Otsuka, Yasuyuki, TEPCO (Japan)

Page, Robert, EDF Energy (U.K.)
Pappas, James, Westinghouse Electric Co.
Parish, Chad, Oak Ridge National Laboratory
Park, Hong
Park, Jaeyeong, Ulsan National Institute of Science and Technology (South Korea)
Pathak, Sid
Payne, Jenna, U.S. Department of Energy
Payne, Liam, Nuclear Waste Services
Peron, Arthur, Institut de Radioprotection et de Sûreté Nucléaire (France)
Pilard, Vincent, TAE Technologies
Place, Jeffrey, Institute of Nuclear Power Operations
Price, Terry, University of Texas–Austin
Pujet, Stephane, Électricité de France (France)

Radev, Radoslav, Lawrence Livermore National Laboratory
Ranta-aho, Anssu, Teollisuuden Voima Oyj (Finland)
Ravat, Olivier
Rea, Steve, NC State University Friends of the Libraries Board
Reed, Michael, U.S. Department of Energy
Reid, Robert
Remus, Andrew
Ridgway, Jefferson, Ultra Electronics–Energy (U.K.)
Rimini, Fernanda, U.K. Atomic Energy Authority
Ritter, Christopher, Idaho National Laboratory
Robison, Seth
Romero, Jesus, TAE Technologies

Saenz Castro, Francisco, Princeton University
Salazar, Alex III
Salazar, Erica, Massachusetts Institute of Technology
Samandari, Navid, Seaborg (Denmark)
Santilli, Ruggero
Schlegel, Fabian, Helmholtz-Zentrum Dresden-Rossendorf (Germany)
Schmitz, Lothar, University of California–Los Angeles
Schroeder, H. R., U.S. Army
Schwanke, Peter (Canada)
Selvamanickam, Venkat, University of Houston
Seylabi, Elnaz, University of Nevada–Reno
Shalaby, Rawda
Shmayda, Walter, University of Rochester
Siman, Aziz, Thermal Engineering International
Sips, Adrianus, General Atomics
Skrecky, Kristin, General Fusion
Smith, Garrett
Smith, Sam, University of Illinois–Urbana-Champaign
Sommer, Fabian
Song, Meiqi (China)
Squire, Michael, University of Texas–San Antonio
Stewart, Craig, American Nuclear Insurers
Sun, Zhen
Swanson, Charles, Princeton Plasma Physics Laboratory

Tak, Giyoung
Tang, Ming, Clemson University
Terek, Justin, Westinghouse Electric Company
Thangavelu, Sonia, Defense Nuclear Facilities Safety Board
Thompson, Matthew, Zap Energy
Toenniessen, Annika, Fluor Corp.

community," Nesbit said. "I believe the positive developments on Diablo Canyon throughout the meeting gave everyone an extra lift—not that we needed it."

Current ANS President Steven Arndt was just as excited during the week of the Annual Meeting. Arndt cohosted the "Celebrating ANS" dinner on Tuesday night, which brought attendees together to relax and reconnect in a community setting. "All the sessions and events were simulating and fun, but the new 'Celebrate ANS' event was so great I think it will be talked about for quite a while to come," Arndt said. "I hope everyone has the opportunity to attend one of our national or topical meetings in the year to come."

Another new feature this year was the career fair, which was well received by both attendees and vendors. The hope is to continue the career fair at future meetings as a means of bringing the younger generation in nuclear into the fold of the wider community. Arndt expressed his pleasure at this addition to the program: "I was delighted to be at the first in-person Annual Meeting in three years, and was particularly pleased to see so many young members and students at the meeting. They are the future of our profession."

New Miss Wisconsin is nuclear energy advocate

Nuclear energy will have an unusually prominent platform in December, when the new Miss Wisconsin, Grace Stanke, competes in the Miss America 2023 competition at the Mohegan Sun Arena in Uncasville, Conn. Stanke, who is a nuclear engineering student at the University of Wisconsin–Madison and an ANS student member, was crowned on June 18. For her social impact initiative speech, Stanke, expressed a desire to advocate for the use of green energy—especially nuclear energy—during her one-year reign as Miss Wisconsin.

Stanke had achieved success in a number of previous pageants leading up to Miss Wisconsin. She won the Miss Wisconsin

ANS News continues

Valentine, Alex, U.K. Atomic Energy Authority
Van Compernolle, Bart
Van der laan, Danko, Advanced Conductor Technologies
Ward, Paul, Kairos Power
Weinstein, Abraham, North Carolina State University
Weisberg, David, General Atomics
Wessels, Steven, American Nuclear Insurers
White, David, Associated Electric Cooperative
Williams, Chad, NuScale Power
Wittel, Madalina
Wohlers, Anke
Wynne, Brian, Princeton University
Yang, Songzhi, Commissariat à l'énergie atomique et aux énergies alternatives (France)
Yoon, Han Young, Korea Atomic Energy Research Institute (South Korea)
Yu, Charley, Argonne National Laboratory
Zhou, Guangming, Karlsruhe Institute of Technology (Germany)
Zipfel, Antonia, Tuev Nord (Germany)
Zou, Xiaoyang, Xi'an Jiaotong University (China)
Zwijsen, Kevin, Nuclear Research and Consultancy Group (The Netherlands)

STUDENT MEMBERS

Excelsior College
Brown, Jacob

Idaho State University
Nguyen, Minh Quang

Massachusetts Institute of Technology
Harmon, Charles
Mazzocco, Lorenzo

North Carolina State University
Boone, Brian

Northeastern University
O'Hearn, Brent

Oregon State University
Gallagher, Nicholas

Pennsylvania State University
Walls, Alicia

Purdue University
Bush, Denver

Reed College
Oliveri, Auden

Rensselaer Polytechnic Institute
Moharana, Avinash

Rockhurst University
Apeldoorn, Abbigale

Texas A&M University
Lee, Jack
Wszolek, Roger

Thomas Edison State College
Cassel, Harlan

University of California–Berkeley
Granados, Matthew

University of Illinois–Urbana-Champaign
Deshpande, Atharva
Kalinichenko, Dimitri

University of Massachusetts–Lowell
Johnson, Paul

University of Michigan
Joynt, Veda

University of Nevada–Reno
Byrne, Ashley

University of North Carolina–Charlotte
Thomas, Lauren

University of Pittsburgh
Barton, Alyssa

University of South Carolina
Al wahaibi, Ayuob

Institution not provided
Diaz Abreu, Angel
Herry, Tanguy

Grace Stanke plays violin during the talent portion of the Miss Wisconsin pageant.

Outstanding Teen competition in 2017 and in 2021 was a semifinalist in the Miss Madison competition. At the time of the 2022 pageant, Stanke was the current Miss Badgerland. For the talent phase of the Miss Wisconsin pageant, Stanke impressed the judges by playing the classical violin in a performance of Vivaldi's "The Storm" from the *Four Seasons*.

The Wausau native came out on top of a field 22 candidates competing for the state crown. "She is an exceptional young woman with a unique combination of intellect, talent, ambition, and relatability," noted Brenda Baudo, the executive director of the Miss Wisconsin Scholarship Organization. As winner of the pageant, Stanke received scholarships worth $12,500, along with a spot on the Miss America stage.

ANS member Paul Wilson, University of Wisconsin–Madison professor of nuclear engineering and chair of the university's Department of Engineering Physics, praised Stanke as "a strong student [who] has been a leader throughout her time on campus." Wilson added that Stanke "has been a co-op at Exelon/Constellation" and "plans to use her position to promote nuclear energy."

After being crowned, Stanke said, "This year, I'm extremely looking forward to promoting my social impact initiative, 'Clean Energy, Clean Future.' As a nuclear engineer, I'm particularly passionate about green energy and switching over the nation and being a world leader in zero-carbon energy. So I'm so excited to represent the state of Wisconsin, root for nuclear energy, and continue on to the Miss America competition."

NRL teams up with ANS to promote nuclear science

The Ohio State University Nuclear Reactor Laboratory (NRL) and the American Nuclear Society student chapter at Ohio State teamed up to provide public outreach to promote understanding about radiation and nuclear science during the annual Center of Science and Industry (COSI) Science Festival, which took place May 4–7 in Columbus, Ohio. COSI developed the free citywide celebration to showcase local science and technology and engage learners of all ages. The event attracts over 20,000 people each year, and the NRL/ANS booth was an interactive opportunity for attendees to see items with naturally occurring radiation, talk to students, and observe hands-on measurement with a radiation meter. Over 200 people of all ages are estimated to have stopped by the booth.

Ohio State student and Department of Energy scholarship recipient Emily Gordon participated in the event right before heading off to her internship at Idaho National Laboratory. Gordon observed that "the word 'nuclear' is sometimes scary for the public, but just like everything else in life, when something is understood and managed properly, it is very safe. Radiation is a part of our everyday lives, and this event was a great opportunity to talk with members of the public about their concerns and make them more comfortable."

"Right here in Columbus, research is happening to support nuclear technology and next-generation advanced reactors research," commented director Dr. Raymond Cao, director of the Nuclear Engineering Program at Ohio State. "NRL is making key contributions and cementing its footprint in these high-impact areas, and this is a great event to talk to general public about what are happening in the labs and to recruit next-generation nuclear talents from a very early stage."

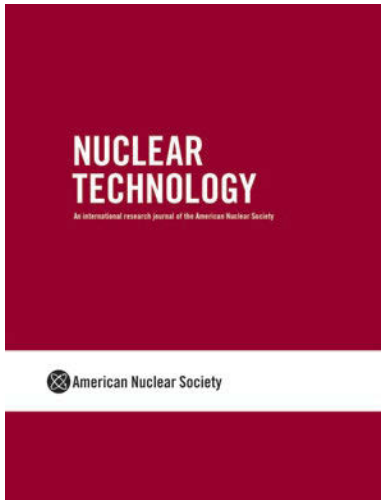
As the only operating research reactor in the state of Ohio, the NRL is a unique teaching and research laboratory that delivers high-quality service to its customers and excellent instruction and research opportunities to nuclear engineering students. In 2017, the DOE designated the NRL as a partner facility of the DOE Nuclear Science User Facilities program, allowing awarded researchers, often in collaboration with other laboratories and industry, to perform DOE mission-supporting research at the NRL at no cost to users.

Nuclear Technology searches for a new technical editor

At the recent ANS Annual Meeting, Andrew Klein, the current editor of ANS's journal *Nuclear Technology*, announced his retirement at the end of his term in June 2023. ANS is looking for qualified members who are interested in becoming the next technical editor of the journal. The selected person will be appointed "editor-designate" and will work with Dr. Klein for a period of time before taking over the full editor's role.

Klein, professor emeritus at Oregon State University and past ANS president, took over the duties of technical editor in 2015, a few years before his term as ANS president. During his tenure as editor, Dr. Klein has raised *NT*'s reputation for technical excellence and arranged a schedule of twelve issues annually covering the most important topics in nuclear technology. Klein said, "It has been an honor and privilege to serve as the editor for *Nuclear Technology* as we successfully partnered with Taylor and Francis as our publisher while continuing to build the quality and significance of the papers that we publish."

All qualified members who are interested in the position or would like further information about the role and responsibilities should see page 151 of this issue, email John Fabian, ANS director of publications (jfabian@ans.org), or visit at ans.org/pubs/journals/nt/editor/ for details and application instructions. All applications must be submitted before October 1, 2022.



Industry

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.*

ADVANCED REACTOR MARKETPLACE

Maryland looks to repurpose coal plant with SMR

The **Maryland Energy Administration** has awarded grants to **X-energy** and **Frostburg State University** to evaluate the suitability of a coal-fired electric power plant site in Maryland for housing X-energy's Xe-100 small modular reactor. The evaluation will consider such factors as environmental benefits; economic viability; stranded asset costs; and job, manufacturing, and construction opportunities in the region. Results of the joint analysis are expected later in 2022.

■ **NuScale Power** has signed a memorandum of understanding with **Associated Electric Cooperative** to evaluate NuScale's VOYGR SMR technology for potential deployment. Associated, based in Springfield, Mo., provides wholesale power to six regional transmission cooperatives and 51 local distribution cooperatives in Missouri, northeastern Oklahoma, and southeastern Iowa.

■ The Czech-based **ČEZ Group** and **ÚJV Řež** research organization have signed an MOU with the South Bohemian government to name a planned SMR development at the Temelin Nuclear Power Station in the Czech Republic as the South Bohemia Nuclear Park. ČEZ is planning construction of the SMRs at the Temelin plant along with new large nuclear reactors at Temelin and at the nuclear facility in Dukovany.

■ **GEH SMR Technologies Canada** has signed an MOU with the **Saskatchewan Industrial and Mining Suppliers Association** to support the possible deployment of BWRX-300 SMRs in Saskatchewan. According to terms of the MOU, the company will collaborate with local suppliers to maximize the province's supply chain for the nuclear energy industry. The agreement stems from a strategic plan for SMR deployment developed by the provincial governments of Saskatchewan, Ontario, New Brunswick, and Alberta.

■ **EDF Nuclear Generation**, the operator of nuclear power plants in the United Kingdom, has awarded a two-year extension to **Jacobs** in the services agreement between the two companies. Jacobs will continue supporting the operation and maintenance of EDF's advanced gas-cooled reactors in the country. The services agreement was in its fourth year of implementation in 2022.

■ Brazil-based **Eletronuclear** and France-based **EDF** have signed a five-year MOU to promote cooperation in the development of nuclear energy projects. The new MOU extends a previous agreement dating from 2018, while expanding the cooperation to include work in SMRs, hydrogen generation, and other research and development. These agreements coincide with the Brazilian government's consideration of expanding nuclear energy beyond the country's sole nuclear power plant at Angra dos Reis.

BUSINESS DEVELOPMENTS

Savannah River opens new regulatory center

Savannah River National Laboratory has established a Regulatory Center of Excellence (RCE) to bring together the enhanced core competencies of the lab and the world-recognized capabilities of the **Battelle Savannah River Alliance**. The SRNL RCE is tasked with reducing environmental risk and liability throughout the Department of Energy complex. Its duties include building a network of experts and researchers to support DOE interactions with regulators and community leaders; supporting other DOE missions that involve complex environmental issues; providing counseling to federal, state, and local partners regarding strategies for environmental cleanup; and strengthening community interactions to mitigate stakeholder concerns.

■ **Uranium Energy** (UEC) has closed a series of transactions with **Anfield Energy**, resulting in UEC settling $18.34 million in debt related to its $112 million acquisition of **Uranium One Americas** in December 2021. Part of the transactions included a property exchange that allowed UEC to consolidate 25 uranium properties, including the Charlie *in situ* recovery uranium project, into its Wyoming portfolio. Anfield acquired UEC's interest in

the Slick Rock uranium-vanadium property in Colorado.

■ France-based **Framatome** has announced its creation of **Framatome Belgium**, a wholly owned subsidiary based in Brussels. The subsidiary will specialize in nuclear engineering and services to support Framatome's life-extension projects, new construction, and dismantling activities for nuclear plants. This work will involve various projects and work sites in Europe.

Framatome has also entered a strategic partnership with France's **National Institute for Research in Digital Science and Technology (Inria)** to accelerate studies focusing on long-term advancements and enhanced safety of operations in the nuclear energy industry. The partners intend to integrate their complementary skills to apply innovative safety technologies to nuclear power plants.

■ The board of directors of **Boss Energy Limited**, headquartered in Perth, Australia, has approved the final investment decision for developing the Honeymoon *in situ* uranium mining project in South Australia. The company plans to speed up its engineering, procurement, and construction activities with the goal of starting production in late 2023. Boss expects the advanced development project to produce 2.45 million pounds of uranium oxide per year.

■ **Doosan Enerbility** of South Korea has agreed to sell its U.K.-based subsidiary, **Doosan Babcock**, to France-based **Altrad**. The transaction, for an undisclosed sum, is expected to conclude in the third quarter of 2022. Doosan Babcock performs engineering, aftermarket, and upgrade services for the nuclear, thermal, oil and gas, and petrochemical industries.

CONTRACTS

DOE awards contracts for decommissioning, waste transport

The Department of Energy's Office of Environmental Management (DOE-EM) has awarded a five-year contract to **Neptune and Company** to support Phase-2 decommissioning decision-making for the West Valley Demonstration Project and Western New York Nuclear Service Center. Neptune is to support the DOE mission at the site in West Valley, N.Y., through the development of probabilistic performance assessment modeling and the statistical decision analysis of proposed decommissioning alternatives.

The DOE-EM has also awarded a contract to **CAST Specialty Transportation** for the acquisition of **Waste Isolation Pilot Plant Transportation Services**. The contract, which is designed to support the DOE's National Transuranic Program to dispose of defense-related transuranic waste, provides facilities, personnel, and equipment to operate a local terminal within a 10-mile perimeter of Carlsbad, N.M., as well as transportation and maintenance services.

■ **Clean Core Thorium Energy** has reached a new strategic partnership agreement with the DOE regarding the testing of the company's proprietary ANEEL (advanced nuclear energy for enriched life) fuel technology. This fuel consists of a combination of thorium and high-assay low-enriched uranium to enhance the performance of CANDU reactors, as well as other pressurized heavy water reactors. **Idaho National Laboratory** plans to begin testing of the ANEEL fuel in its Advanced Test Reactor by early 2023.

■ U.S.-based **Constellation** and **GLE,** a joint venture between the Australian company **Silex** and the Canadian company **Cameco**, have signed a letter of intent to assess potential areas of cooperation. These areas include GLE's deployment of separation of isotopes by laser excitation (SILEX) technology in the United States, as well as diversification of uranium conversion and enrichment capabilities and capacity in the U.S.

■ Ontario-based **BWXT Medical** and **TRIUMF**, Canada's particle accelerator center, have reached a licensing and services agreement for BWXT to manufacture pharmaceutical and biotechnology products based on high-purity actinium-225. The agreement extends BWXT's work in medical isotope production at the TRIUMF site in Vancouver, British Columbia.

■ **Toshiba America Energy Systems** and **Toshiba Energy Systems and Solutions** have signed an MOU with **Bechtel Corporation** to pursue a new nuclear power plant project in Poland. With this MOU, Toshiba joins a group of U.S. and Polish companies, led by Bechtel and **Westinghouse Electric Company**, that is supporting the Polish government's plans to construct its first nuclear power facility. The

Industry continues

group is currently preparing a front-end engineering design for a three-unit plant, using Westinghouse AP1000 pressurized water reactors, to be located on the Baltic Sea coast.

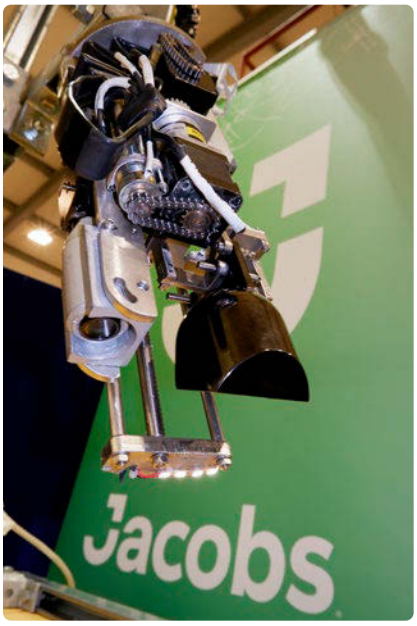
■ **Korea Electric Power Corporation** (KEPCO) has reached an agreement with **Westinghouse** to cooperate in international nuclear power markets to advance South Korea's goal of exporting 10 nuclear power plants by 2030. Westinghouse, KEPCO, and KEPCO's subsidiary **Korea Hydro and Nuclear Power** are establishing a joint working group to develop detailed plans to meet this objective. This agreement was reached one week after Westinghouse signed a strategic cooperation agreement with South Korea's **Hyundai Engineering and Construction** to jointly participate in international opportunities involving Westinghouse AP1000 reactors.

NEW PRODUCTS

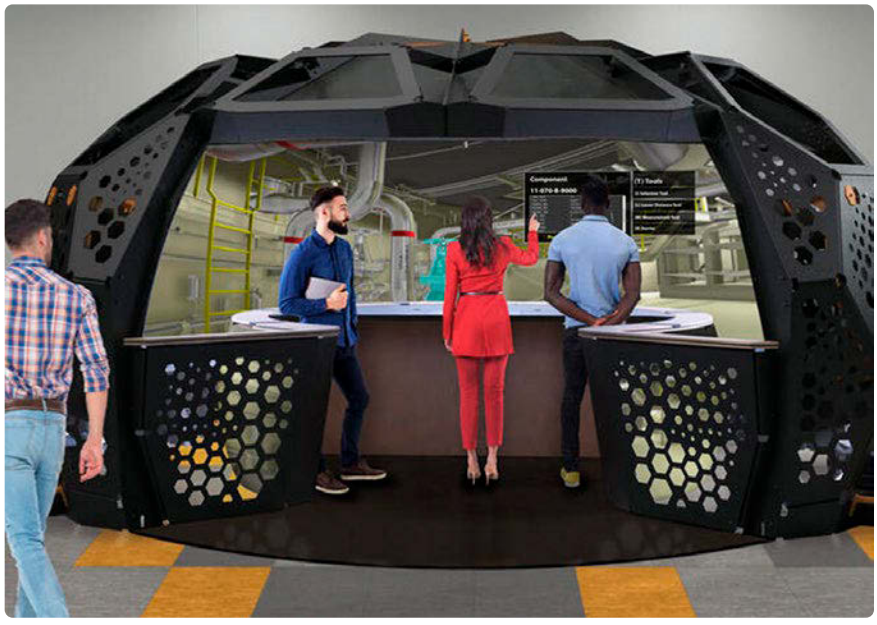
Jacobs robot to evaluate damaged reactor containment vessel

Engineers with **Jacobs** have designed a remotely operated robotic device for use at Japan's Fukushima Daiichi nuclear power plant. The device, controlled by an operator watching video images produced by a built-in camera, will collect pebble-like debris from the bottom of a damaged reactor containment vessel for evaluation. The results will help investigators determine the next steps in the cleanup and decommissioning process. The robotic project is being led by **Mitsubishi Heavy Industries**, with funding from Japan's Ministry of Economy, Trade, and Industry.

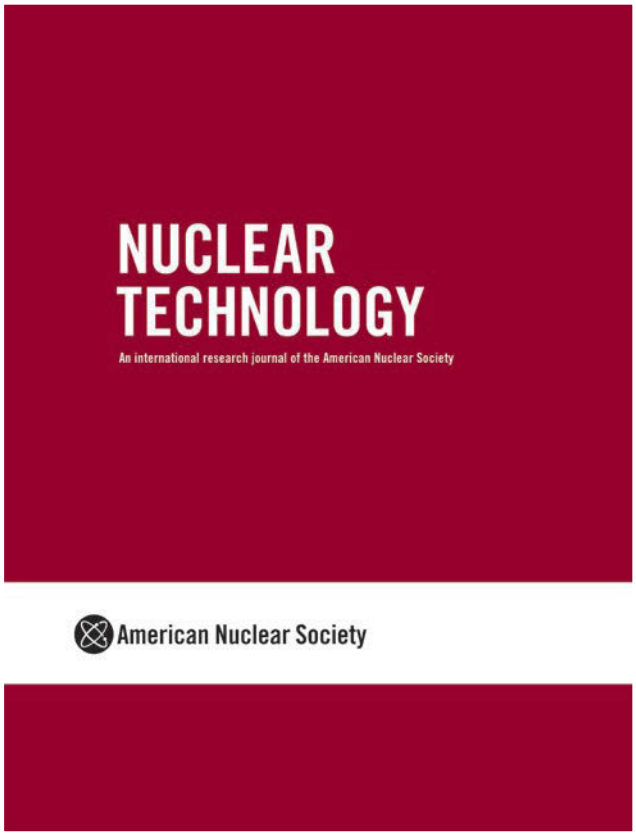
■ **Duke Energy One** and **L3Harris Technologies** are together offering a new service to provide 3D simulations of nuclear power plants to help operators enhance preparedness, efficiency, safety, and cost reduction. Duke Energy One first uses the laser-scanning technology of its 3D Metrology Services program to customize three-dimensional models of each power plant. L3Harris then combines the data from these models with immersive, collaborative environments to produce suites of decision-making tools that can be applied to scenarios authoring, radiation simulation, live simulation links, data enhancement, and resource planning integration. The immersive simulations can also be used with L3Harris's Orchid IX display technology to create realistic virtual environments without headsets.



Jacobs's remotely operated robotic device.


L3Harris's Orchid IX 3D immersion display.

NUCLEAR TECHNOLOGY
SEEKS EDITOR-DESIGNATE



The American Nuclear Society (ANS) is soliciting qualified members who are interested in becoming the editor of Nuclear Technology (NT). Dr. Andrew C. Klein, Oregon State University, has served as editor of NT since July 2015. During his term, Dr. Klein has raised NT 's reputation for technical excellence and arranged a schedule of twelve issues annually covering the most important topics in nuclear technology.

Dr. Klein has indicated that he intends to step down from the editorship effective July 1, 2023, providing an opportunity for another to serve as editor. Consequently, ANS is seeking a qualified individual to fill this position. The selected person will be appointed "Editor-Designate" and will work with Dr. Klein for a period of time before taking over the full editor's role.

It is the responsibility of the editor of NT to maintain the technical quality of the journal. The responsibilities of the position include reviewing submitted papers for content and appropriateness, selecting suitable reviewers for detailed technical review of each paper, reading reviewers' comments and recommendations, and determining the outcome of the submission (acceptance as is, required revision and re-review, or rejection). The editor also sets the technical direction of the journal by soliciting papers, special issues, and reviews on important and timely technical topics. The editor is expected to be proactive in obtaining manuscripts such that a sufficient number of high-quality manuscripts on appropriate and timely topics are considered for publication. The editor will work with the ANS Publications Department staff, forecasting the future volume of papers for planning purposes.

The role of the editor is primarily technical leadership and direction. Past experience indicates that this requires at least 8 hours per week, plus attendance at the two ANS national meetings and approximately two topical meetings per year. The editor meets with and reports to the ANS Technical Journals Committee (TJC) at the ANS national meetings each year. The editorial and administrative work associated with publishing NT (receiving manuscripts, transmitting manuscripts to reviewers, following up to get reviews back, copyediting, typesetting, and printing) is carried out by ANS and publishing partner Taylor & Francis.

ANS pays the editor a small honorarium, provides a travel budget to attend the required meetings, and pays communications costs as needed.

Candidates for editor must be knowledgeable and respected members of the nuclear technology community and members (in good standing) of ANS. They must have experience with and appreciation for the role of research and journal publication in the area of nuclear science.

Individuals who are qualified and interested in this vital position are requested to electronically submit the following documents to jfabian@ans.org:

1. cover letter highlighting the applicant's interest in and suitability for the position—one page maximum;
2. statement of editorial approach: brief summary of the applicant's approach toward executing the responsibilities of editor, in particular, specific plans for ensuring that NT will continue to thrive over the next decade—two pages maximum;
3. full curriculum vitae including list of publications—no page limit.

For full consideration, applications must be received by October 1, 2022. Receipt of an application will be acknowledged via email reply. Queries about this opportunity should be directed to Dr. Robert Little, TJC Chair, rlc@lanl.gov. Interviews of the prospective candidates by the TJC are expected to be held in November 2022 at the ANS Winter Meeting in Phoenix, Arizona.

Standards

ANS revises criticality safety standard for storage of fissile materials

The ANS Standards Committee has recently published ANSI/ANS-8.7-2022, *Nuclear Criticality Safety in the Storage of Fissile Materials* (revision of ANS-8.7-1998 [R2017]). Approved May 6, 2022, by the American National Standards Institute, this standard provides general storage criteria based on validated calculations and includes some engineering and administrative practices appropriate to the storage of fissile material. Mass and spacing limits are tabulated for uranium containing greater than 30 weight per onium, as metals and oxides. Criteria for the range of application of these limits are provided.

When dealing with fissile material, the application of some of the mass limits and allowances permitted in storage arrangements requires groups or individuals experienced in nuclear criticality safety to examine the contingencies attendant to handling massive pieces, to deviations from established procedures, or to those perturbations or mishaps commonly encountered in storage areas. This standard should be considered not as a substitute for detailed safety analyses, but rather as an integral part of the analysis for the attainment of a sound nuclear criticality safety program.

The ANS-8.7 Working Group under the ANS Fissionable Material Outside Reactors Subcommittee (ANS-8) was established in November 1967 and has published several versions of this standard, most recently in 1998. The 2022 revision makes textual enhancements to bring consistency between this standard and the current series of ANS-8 standards. No changes to the calculation limits have been made. ANSI/ANS-8.7-2022 is an extension of ANSI/ANS-8.1-2014 (R2018), *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors*.

Check out a preview or purchase ANSI/ANS-8.7-2022 in the ANS Standards Store at techstreet.com/ans.

Ballots issued

■ ANS-19.4-2017 (R202x), *A Guide for Acquisition and Documentation of Reference Power Reactor Physics Measurements for Nuclear Analysis Verification* (reaffirmation of ANSI/ANS-19.4-2017).

This standard specifies and provides requirements for the reference measurements of reactor geometry, reactivity, and operation parameters in light water power reactors. The measurement data are used in the verification of reactor physics computational methods used for nuclear core designs and analyses. The standard identifies the types of parameters, a brief description of test conditions and experimental data required for such reference measurements, problems and concerns that may affect the accuracy or interpretation of the data, and criteria to be used in documenting the results of reference measurements.

■ ANS-8.5-1996 (R202x), *Use of Borosilicate-Glass Raschig Rings as a Neutron Absorber in Solutions of Fissile Material* (reaffirmation of ANSI/ANS-8.5-1996 [R2017]).

This standard provides guidance for the use of borosilicate-glass Raschig rings as a neutron absorber for criticality control in ring-packed vessels containing solutions of uranium-235, plutonium-239, or uranium-233. The chemical and physical environment, properties of the rings and packed vessels, maintenance inspection procedures, and operating guidelines are specified.

■ ANS-8.6-1983 (R202x), *Safety in Conducting Subcritical Neutron-Multiplication Measurements In Situ* (reaffirmation of ANSI/ANS-8.6-1983 [R2017]).

This standard provides safety guidance for conducting subcritical neutron-multiplication measurements where physical protection of personnel against the consequences of a criticality accident is not provided. The objectives of *in situ* measurements are either to confirm an adequate safety margin or to improve an estimate of such a margin. The first objective may constitute a test of the criticality safety of a design that is

based on calculations. The second may affect improved operating conditions by reducing the uncertainty of safety margins and providing guidance to new designs.

Approved

■ ANSI/ANS-19.11-2017 (R2022), *Calculation and Measurement of the Moderator Temperature Coefficient of Reactivity for Pressurized Water Reactors* (reaffirmation of ANSI/ANS-19.11-2017).

This standard provides guidance and specifies criteria for determining the moderator temperature coefficient of reactivity (MTC) in water-moderated power reactors. Measurement of the isothermal temperature coefficient of reactivity (ITC) at hot-zero-power (HZP) conditions is covered in ANSI/ANS-19.6.1-2019, *Reload Startup Physics Tests for Pressurized Water Reactors.* This standard therefore addresses the calculation of the ITC at HZP and the calculation and measurement of the MTC at power. At present, this standard addresses the calculation and measurement of the MTC only in PWRs, because that is the only type of power reactor currently sited in the United States for which measurement of the MTC is required.

Published

■ ANSI/ASME/ANS RA-S-1.1-2022, *Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications* (supersedes ASME/ANS RA-S-2008 [R2018]).

This standard states requirements for a Level 1 probabilistic risk assessment of internal and external hazards while at power for the evaluation of core damage frequency. In addition, this standard states requirements for a limited Level 2 PRA sufficient to evaluate large early release frequency. The only hazards explicitly excluded from the scope are accidents resulting from purposeful human-induced security threats (e.g., sabotage, terrorism). These requirements are written for operating light water reactor power plants. This standard may be used for LWR plants under design or construction or for advanced LWRs, but revised or additional requirements may be needed.

Volunteer support needed

The following standards projects need 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 ANSI/ANS-2.17-2010 [R2021]).

■ ANS-2.18, *Standards for Evaluating Radionuclide Transport in Surface Water for Nuclear Power Sites* (proposed new standard).

■ ANS-8.14, *Use of Soluble Neutron Absorbers in Nuclear Facilities Outside Reactors* (revision of ANSI/ANS-8.14-2004 [R2021]).

■ 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 [R2021]).

■ ANS-56.2, *Containment Isolation Provisions for Fluid Systems After a LOCA* (new standard, revision of ANS-56.2-1984 [W1989]).

■ ANS-58.16, *Safety Categorization and Design Criteria for Nonreactor Nuclear Facilities* (revision of ANSI/ANS-58.16-2014 [R2020]).

Direct Answer

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Why Japan's response to Fukushima radiation failed while Utah's response succeeded

By James Conca

In 1953, the United States detonated aboveground nuclear weapons during tests at the Nevada Test Site. In 2011, the Fukushima Daiichi meltdown occurred in Japan. Both events spread radioactive material over many miles and over population centers. Neither event resulted in any adverse health effects from that radiation.

Aboveground atomic bomb test at the Nevada Test Site while troops look on. These clouds of material often wafted over to Utah during the 1950s. (Photo: NNSA)

But the response to the Fukushima event was disastrous because of the irrational and misinformed fear of radiation. That fear—not radiation—killed at least 1,600 people and destroyed the lives of at least another 200,000. That fear seriously harmed the entire economy of Japan, stopped cold the fishing industry and other agriculture in that area, and, overnight, reversed the country's progress in addressing climate change.

The U.S. tests spread two to three times more radiation than did the events of Fukushima over the people of Utah, particularly the town of St. George. Like with Fukushima, no one was hurt, there was never any increase in cancer rates, and no one died as a result. But in Utah, the economy and people's lives were unaffected. Why was there such a different result?

The answer is obvious to famous radiobiologist Dr. Antone Brooks. In the 2020 article for the *International Journal of Radiation Biology*, "Cost of fear and radiation protection actions: Washington County, Utah and Fukushima, Japan," Brooks and his coauthor, Bruce Church, compared the effects of radioactive fallout from 1953 atomic bomb testing in Washington County, Utah, to that of the Fukushima accident.

Even after receiving much higher radiation doses than those in Japan, the city of St. George, Utah, asked the people to simply shelter in place for a while. No other action was taken, although people washed off their cars right afterward. There were no health effects. Cancer rates in Washington County have always been among the lowest in Utah, which has the lowest cancer rates in the entire United States. Hundreds of similar tests occurred over many years, with similar

actions (or inactions, as the case may be) taken by the population, and with similar end results (or lack thereof).

But in Japan, about 160,000 people were hastily and carelessly evacuated and 1,600 quickly died from that forced evacuation alone. The rest had their lives pretty much destroyed. The rest of Japan was harmed economically, and the population's health has been adversely affected by the ramp-up of coal use because of unnecessarily shutting down all their nuclear power plants.

The Fukushima response is one of the greatest bureaucratic, regulatory, and administrative failures in history—because science was trumped by fear.

Many of us in the nuclear field understand that the fear of nuclear is one of the oldest conspiracy theories in modern times, perpetrated by being blindly cemented in the world's administrative controls over nuclear since the 1950s. Often, such nonsense doesn't hurt a lot of people, but lately, we have begun to understand how widespread, purposeful misinformation can wreak havoc on a democratic society.

Brooks and Church, both of whom grew up in Washington County, Utah, determined radiation exposures and doses resulting from the Nevada nuclear weapons tests from published reports, papers, and historical records. Recent publications were used to define the doses following Fukushima (see their paper at doi.org/10.1080/09553002.2020.1721595 for methodology). The maximum dose rate in St. George was 3.5 mSv/h (May 19, 1953), while in Fukushima it was about 1–10 mSv/h at the main gate on March 11, 2011—and four days later, on March 15, 2011, about 25 miles downwind, it was 0.045 mSv/h.

The authors chose not to include internally deposited radioactive materials in the dose calculations since they depend on many models and assumptions. However, if the dose from internal emitters had been included, the doses in southern Utah would have been much higher than those in Fukushima due to the extensive contamination in Utah with strontium-90, cerium-144/praseodymium-144, cesium-137, and iodine-131, as well as several alpha emitters like plutonium-239 and americium-241 along with other short-lived radionuclides, most of which were not present at Fukushima.

The explosions that spread material from the Fukushima meltdown were hydrogen gas explosions, not nuclear. (Photo: Wiki Fandom)

In their 2015 report "The Fukushima Health Management Survey: Estimation of external doses to residents in Fukushima Prefecture," Tetsuo Ishikawa and his coauthors found that the individual doses to 423,394 Japanese residents during the first four months had the following distribution: 62.0 percent under 1 mSv, 94.0 percent under 2 mSv, and 99.4 percent under 3 mSv. These are small doses—around or below background levels—and have never been shown to have any adverse health effects on humans or animals. In both cases, the exposures were protracted, and it is well established that protracted radiation exposure decreases the risk of cancer (see, for example, the 2006 report by the National Research Council titled *Health Risks from Exposure to Low Levels of Ionizing Radiation*).

For comparison, the doses from computed tomography (CT) scans range from 20 mSv for a chest CT to a high of almost 100 mSv for a full body scan. There are over 90 million CT scans performed each year in the United States, with no increased adverse health effects. The difference is that an individual chooses to have a CT scan but has no say or choice in receiving the exposure from a nuclear reactor accident or an atomic bomb test, so the latter are perceived as more frightening.

Opinion continues

Opinion

So why did Japan overreact and cause more harm to their citizens than the Fukushima radiation could ever do, while Utah did not? Because since the 1950s, the world has adopted a set of models and regulations based on an idea called the linear no-threshold (LNT) dose hypothesis, which was not based on science. LNT implies that all radiation is harmful, even at very low doses, which is not correct. LNT generated and amplified the fear of any radiation to amazing levels in the minds of citizens and their leaders.

Utah in 1953 was not infected with the LNT ideology and took appropriate actions actually based on science.

Since the start of the atomic age, extensive studies on both the early and late effects of radiation have been conducted on almost every type of animal, including humans, and at every level of biological organization, from molecules to cells to individual organs to whole organisms, in order to see the influence of dose and dose rate on radiation-induced biological changes.

The development of modern molecular and cellular biology, combined with new technology, made it possible to measure biological responses in the low-dose and low-dose-rate regions. The application of these techniques to low doses and dose rates by the Department of Energy Low Dose Radiation Research Program is summarized by Brooks in his 2018 book *Low Dose Radiation: The History of the U.S. Department of Energy Research Program*. Similar approaches have been used in the European Union, Korea, and Japan.

All this research demonstrated the need for the hit theory to be replaced by more of a systems approach, with bystander effects and cell-cell and cell-tissue communication playing a major role in the biological response to radiation. The data taken demonstrated that the biological responses and the mechanisms of action following exposure for low doses are very different from the responses to high doses.

Low-dose and high-dose responses activate a different set of genes and activate different proteins and metabolic pathways (Dauer and colleagues discuss this in a 2010 article published in *Radiation Protection Dosimetry* [doi.org/10.1093/rpd/ncq141]), suggesting unique mechanisms of action as a function of both dose and dose rate, mechanisms that are effective at mitigating radiation damage at low doses (< ~20 rem per year; < ~0.2 Sv per year) but less and less effective as doses climb above this.

These observations do not support the use of LNT as being scientifically accurate, so LNT should not be used for risk assessment or making judgments on actions to be taken following accidents or other events where populations exposed to low doses delivered at low dose rates may result in drastic unwarranted actions, like evacuation. And the United Nations Scientific Committee on the Effects of Atomic Radiation now agrees, according to the second volume of that body's 2020–2021 report.

Radiation is a very good cell killer, which is why we use it at high doses in cancer therapy. But fear—and the biological consequences and the regulatory actions triggered by that fear generated from LNT—of low doses of radiation remains the major biological damage induced by low-dose and low-dose-rate radiation exposures (see, e.g., "The high price of public fear of low-dose radiation" by Waltar et al. in the *Journal of Radiological Protection* [doi.org/10.1088/0952-4746/36/2/387]).

So, it is no wonder that Japan failed, and continues to fail, while Utah did just fine.

James Conca is a scientist in the field of 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. He is a former contributor to Forbes*; you can view his past stories online at forbes.com/sites/jamesconca.*

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People


Hayes

Mahdi Hayes has been selected by the Nuclear Regulatory Commission as the new senior resident inspector at California's Diablo Canyon nuclear power plant. Hayes has been with the NRC since 2006, when he became a reactor engineer in the Nuclear Safety Professional Development Program. From 2009 to 2013, he was resident inspector at the Columbia nuclear plant in Washington state. He then became an operations engineer and operator license examiner in the NRC Region IV office in Arlington, Texas.

The NRC has named **Anthony Smallwood** as the new resident inspector for the Grand Gulf nuclear plant in Port Gibson, Miss. Smallwood, who joined the NRC in 2020, previously was an engineer in the automobile, oil, and gas industries. He is also a veteran of the U.S. Navy.


Smallwood


Jackson

Former NRC chair (1995–1999) **Shirley Ann Jackson** retired as president of the Rensselaer Polytechnic Institute on June 30. Jackson became the first African American woman to head a major U.S. research university when she took over the reins of RPI in 1999. She went on to serve the second-longest presidential tenure in the 198-year history of the university.


Heflin

Arizona Public Service Co. has named **Adam Heflin** as the executive vice president and chief nuclear officer at the utility's Palo Verde nuclear plant. Heflin takes over from **Maria Lacal**, who announced her intention to retire. Heflin was previously the CEO and CNO at the Wolf Creek Nuclear Operating Corporation and before that the CNO at Ameren's Callaway Energy Center. He has also served on the boards of the Nuclear Energy Institute and the Institute of Nuclear Power Operations.


Lacal

The board of directors of Utah Associated Municipal Power Systems has appointed **Mason Baker** as the company's new chief executive officer and general manager, effective in January 2023. Baker replaces the retiring **Douglas Hunter**, who had been with UAMPS for 39 years. Baker joined UAMPS in 2011 as chief legal officer and general counsel and has played a major role in UAMPS's Carbon Free Power Project, which is planning a small modular reactor at Idaho National Laboratory.


Baker


Hunter


Sundararajan

American Electric Power has named **Raja Sundararajan** as its new executive vice president, external affairs. He has been with AEP since 2002 and was most recently the company's senior vice president, regulatory and customer solutions. Sundararajan takes over leadership of AEP's communications and marketing, customer, regulatory, federal public policy, and Ohio government affairs groups.


Martin

AEP has also named **Steven Martin** as its new vice president, infrastructure engineering, IT operations, and support. In this position, Martin oversees technology planning and delivery for infrastructure technologies, such as computer, network, storage, and end-user tools. Martin was

previously vice president of technology enterprise services for JCPenney and managing director at JCPenney Services India.


Novak

Vladimir Novak has been selected as the new chief commercial officer for Ultra Safe Nuclear, responsible for setting corporate strategy and leading commercial growth across global markets. Novak had previously spent 14 years with Chevron, where he held several senior positions. He also filled leadership roles in technology and business development at General Electric.


Smith

Candu Energy, of the SNC-Lavalin Group, has appointed **Stephanie Smith** as senior vice president of engineering for SNC-Lavalin's Canadian nuclear business. Smith replaces **Kevin Jones**, who retired. One of Smith's duties is transitioning the nuclear engineering group from an operations-oriented model to a client-service, competitive, growth-oriented culture. She was previously the president and CEO of the CANDU Owners Group, and she held senior positions with Ontario Power Generation.


Machtou

Nicolas Machtou has been named as the first director of the New Nuclear Program for France, part of a reorganization of EDF's Engineering and New Nuclear Projects Division. His responsibilities as director focus on leading project management of the construction programs for new EPR2 reactors in France. Machtou has previously held a number of high-level positions in industry and government, including advisory roles in the offices of the French president and prime minister and, most recently, as chairman of the board of directors of Citelum (in the EDF Group).


Gonzalez

The Council of Ministers of the Spanish government has appointed **Pablo Martin Gonzalez** as secretary general of Spain's Nuclear Safety Council. The appointment had been proposed by **Teresa Ribera**, minister for the ecological transition and demographic challenge. Gonzalez served as undersecretary of the Spanish Ministry of Science, Innovation, and Universities from June 2018 to March 2022.

Obituaries


Talnagi

Joseph W. Talnagi, 68, ANS member since 1981; research scientist; worked for many years at the Ohio State University Nuclear Reactor Laboratory; also taught at OSU; operated his own consulting company after retirement; died on February 17, 2021.

Joseph W. Glaser, 71, ANS member since 2002; graduated from the State University of New York at Stony Brook; obtained doctorate degree specializing in reactive flows/laser diagnostics from the Polytechnic Institute of New York University; performed work on isotope enrichment at Lawrence Livermore National Laboratory before moving to the Office of Nuclear Physics at the DOE; senior advisor with the DOE National Nuclear Security Administration's Highly Enriched Uranium Transparency Program, which dismantled surplus Russian nuclear weapons for peaceful energy production; retired in December 2020; died on May 11, 2022.

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. 1–3—**2022 Nuclear Information Management Symposium**, Las Vegas, Nev. nirma.org/annual-symposium/

Aug. 3–5—**The Energy Communities Forum on Hosting New Nuclear Development**, Salt Lake City, Utah. energyca.org/events/ecaforum

Aug. 7–10—**Utility Working Conference and Vendor Technology Expo**, Marco Island, Fla. ans.org/meetings/uwc2022

Aug. 8–12—**29th International Conference on Nuclear Engineering (ICONE 29)**, Shenzhen, China. event.asme.org/ICONE

● Aug. 9–11—**Diesel Fuel Owners Group (DFOG) Annual Meeting**, San Antonio, Texas. Contact: Tawanna Harley, tharley@mpr.com

Aug. 21–24—**2022 Fuel Conference**, Ajax, Ontario, Canada. cns-snc.ca/events/2022-fuel-conference/

✖ Aug. 28–Sep. 1—**PATRAM 2022 (Packaging and Transportation of Radioactive Materials Symposium)**, Nice, France. patram.org/
Meeting postponed to June 11–16, 2023

September

● Sep. 5–10—**13th International Topical Meeting on Nuclear Reactor Thermal Hydraulics, Operation and Safety (NUTHOS-13)**, virtual event. nuthos-13.org/
Meeting converted from in person to fully online

Sep. 7–9—**World Nuclear Association Symposium 2022**, London, United Kingdom. wna-symposium.org/

Sep. 13—**Small and Advanced Reactors 2022**, virtual event. pmi-live.com/events/small-and-advanced-reactors2022/

Sep. 19–21—**Fontevraud 10 International Symposium on Contribution of Materials Investigations and Operating Experience to LWRs' Safety, Performance and Reliability**, Avignon, France. new.sfen.org/evenement/fontevraud-10/

Sep. 19–23—**16th International Conference on Scintillating Materials and Their Applications (SCINT)**, Santa Fe, N.M. conferences.ieee.org/conferences_events/conferences/conferencedetails/51553

✖ Sep. 21–22—**Energy 2050 Summit**, London, United Kingdom and online. frontierenergy.network/events/energy-2050-summit-2022
Meeting postponed to Nov. 23–24, 2022

■ Sep. 25–29—**14th International Conference on Radiation Shielding and 21st Topical Meeting of the Radiation Protection and Shielding Division**, Seattle, Wash. ans.org/meetings/icrs14rpsd22/

Sep. 27–28—**International Power Summit 2022**, Munich, Germany. registration.pmi-live.com/tc-events/international-power-summit-2022/

October

Oct. 3–6—**4th International Conference on Generation IV and Small Reactors (G4SR-4)**, Toronto, Ontario, Canada. g4sr.org/

Oct. 3–6—**Experience POWER**, Denver, Colo. experience-power.com/

Oct. 4–6—**ETEBA Business Opportunities & Technical Conference**, Knoxville, Tenn. eteba.org/BOTC/

● Oct. 6–7—**2nd Annual Small Modular Reactors (SMR) 2022**, virtual event. prosperoevents.com/event/2nd-annual-small-modular-reactors-smr-2022/

■ Oct. 9–13—**TopFuel 2022**, Raleigh, N.C. ans.org/meetings/topfuel2022/

● Oct. 18–21—**International Conference on Topical Issues in Nuclear Installation Safety: Strengthening Safety of Evolutionary and Innovative Reactor Designs**, Vienna, Austria. iaea.org/events/tic-2022

Oct. 24–28—**NuMat2022: The Nuclear Materials Conference**, Ghent, Belgium. elsevier.com/events/conferences/the-nuclear-materials-conference

Oct. 26–28—**International Ministerial Conference on Nuclear Power in the 21st Century**, Washington, D.C. iaea.org/events/ministerial-nuclear-power-conference-2022

● Oct. 27–29—**3rd International Conference on Advances in Energy Research and Applications (ICAERA'22)**, virtual event. icaera.com/
Meeting converted from in person to fully online

Oct. 31–Nov. 4—**65th Annual Radiobioassay and Radiochemical Measurements Conference (RRMC)**, Atlanta, Ga. rrmc.co/

November

Nov. 1–3—**3rd Annual International Conference on AI, ML and Other Innovative Technologies in the Nuclear Industry**, virtual event. cns-ai-nuclear.com/

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

- Nov. 13–17—**2022 ANS Winter Meeting and Technology Expo**, Phoenix, Ariz. ans.org/meetings/wm2022/
- Nov. 13–17—**International High-Level Radioactive Waste Management**, Phoenix, Ariz. ans.org/meetings/ihlrwm2022/
- Nov. 23–24—**Energy 2050 Summit**, London, United Kingdom and online. frontierenergy.network/events/energy-2050-summit-2022

  Nov. 27–Dec. 1—**RSNA 2022**, Chicago, Ill. rsna.org/annual-meeting

  Nov. 28–29—**7th World Nuclear Industry Congress 2022 (WNIC 2022)**, London, United Kingdom, szwgroup.com/nuclear-industry-congress-uk/
- Nov. 28–Dec. 2—**5th International Conference on Nuclear Power Plant Life Management**, Vienna, Austria. iaea.org/events/plim-5

  Nov. 29–Dec. 1—**Valve World Expo 2022**, Düsseldorf, Germany. valveworldexpo.com/

December

Dec. 13–16—**Integrated Medical Imaging in Cardiovascular Diseases (IMIC-2022)**, Vienna, Austria. iaea.org/events/imic2022

January 2023

Jan. 24–26—**20th Annual USA Member & Supplier Partner Winter Conference**, Savannah, Ga. usainc.org/winter-conference/

February

- Feb. 6–9—**Conference on Nuclear Training and Education: A Biennial International Forum (CONTE 2023)**, Amelia Island, Fla. ans.org/meetings/view-conte23/
- Feb. 21–23—**PowerGen International**, Orlando, Fla. powergen.com/welcome
- Feb. 26–Mar. 2—**WM2023 Symposia**, Phoenix, Ariz. wmsym.org/

20th International Topical Meeting on Nuclear Reactor Thermal Hydraulics (NURETH-20)

August 20-25, 2023 | Washington, DC, USA | Washington Hilton

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ABSTRACT DEADLINE: OCTOBER 1, 2022

OCTOBER → SUBMISSION OF ABSTRACTS: **October 1, 2022**
NOVEMBER → AUTHOR NOTIFICATION OF ACCEPTANCE: **November 1, 2022**
JANUARY → DRAFT PAPERS: **January 1, 2023**
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GUIDELINES

The limit for abstract submissions is 250 words. The limit for full-paper submissions is 14 pages. Papers exceeding 14 pages will be rejected. If an exception is made and a paper over 14 pages is accepted, page charges are $100/page for p. 15 and above. The conference proceedings will be distributed digitally. Selected papers will be published in the special issues of *Nuclear Technology*, *Nuclear Science and Engineering*, *Fusion Science and Technology*, and *Nuclear Engineering and Design*.

ABOUT THE MEETING

NURETH is the premier gathering for experts in nuclear reactor thermal hydraulics and related topical areas. This meeting is held every two years. The Washington DC ANS Section is pleased to host NURETH-20 in Washington, DC, USA. Washington, DC is more than the capital of the USA– it is the center of both support and regulation of the nuclear industry. Washington DC is not only a center of government but also a tremendous visitor center with cultural attractions for all.

NURETH-20 HOSTS

Raymond Furstenau, USNRC
Yassin Hassan, Texas A&M
Stephen M. Bajorek, USNRC

SUBMIT AN ABSTRACT

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PROGRAM SPECIALIST

Janet Davis
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20th International Topical Meeting on Nuclear Reactor Thermal Hydraulics (NURETH-20)

August 20-25, 2023 | Washington, DC, USA | Washington Hilton

TECHNICAL TRACKS

HIGH-QUALITY PAPERS (14-PAGE MAXIMUM) ARE SOLICITED IN THE FOLLOWING AREAS:

1. FUNDAMENTAL THERMAL HYDRAULICS
   - 1A. Two-Phase Flow and Heat Transfer
   - 1B. Boiling and Condensation
   - 1C. Interfacial Area Transport
   - 1D. Critical Heat Flux and DNB
   - 1E. Natural Circulation in Reactor Systems
   - 1F. Thermal Hydraulic Scaling
   - 1G. General

2. COMPUTATIONAL THERMAL HYDRAULICS
   - 2A. Thermal Hydraulics System Code Development and Analysis
   - 2B. Computational Fluid Dynamics (CFD)
   - 2C. Multiphase CFD
   - 2D. Multiphysics Development and Applications
   - 2E. DNS for Model Development
   - 2F. Multiscale CFD and Coupling with System Codes
   - 2G. Subchannel Thermal Hydraulic Analysis
   - 2H. General

3. EXPERIMENTAL THERMAL HYDRAULICS
   - 3A. Experimental Methods and Instrumentation
   - 3B. Integral and Separate Effects Tests
   - 3C. Tests for Assessment of CFD
   - 3D. Experimental Databases and Preservation
   - 3E. Experiments for Advanced and Special Purpose Reactors
   - 3F. Rod Bundle Experiments
   - 3G. Critical Heat Flux and Post-CHF Experiments
   - 3H. UQ Methods and Best Practices for Experiments
   - 3I. General

4. VERIFICATION, VALIDATION AND UNCERTAINTY QUANTIFICATION (VVUQ)
   - 4A. Verification and Validation of Systems Codes
   - 4B. Verification and Validation of Subchannel Codes
   - 4C. Best Practices in CFD
   - 4D. Uncertainty Methodology Development
   - 4E. BEPU Analysis and Challenges in Licensing
   - 4F. General

5. WATER-COOLED REACTOR OPERATIONS AND ANALYSIS
   - 5A. LWR Operation and Safety Analysis
   - 5B. HWR Operation and Safety Analysis
   - 5C. VVER Operation and Safety Analysis
   - 5D. BWR Instabilities and Nonlinear Dynamics
   - 5E. Small Modular LWRs
   - 5F. General

6. SEVERE ACCIDENTS
   - 6A. Severe Accident Scenarios and Source Term
   - 6B. In-Vessel Corium and Debris Bed Coolability
   - 6C. Ex-Vessel Corium Interaction and Coolability
   - 6D. Containment TH, Hydrogen and Fission Product Behavior
   - 6E. Design Features to Prevent Severe Accidents
   - 6F. Uncertainty in Severe Accident Modeling
   - 6G. Severe Accidents in Advanced Reactors and Nuclear Installations
   - 6H. General

7. NEW AND ADVANCED REACTORS
   - 7A. High-Temperature Gas Cooled Reactors
   - 7B. Liquid Metal Cooled Reactors
   - 7C. Molten Salt Reactors
   - 7D. Supercritical Water Cooled Reactors
   - 7E. Microreactors
   - 7F. Reactors for Space Applications
   - 7G. Offshore Nuclear Platforms
   - 7H. Advanced Reactor Fuel
   - 7I. General

8. SPECIAL TOPICS
   - 8A. Hydraulics in Medical Isotope Production
   - 8B. Fluid-Structure Interactions
   - 8C. Accident Tolerant Fuel
   - 8D. Machine Learning and Artificial Intelligence for TH
   - 8E. Test and Prototype Reactors
   - 8F. Thermal Hydraulics of Fusion Reactors
   - 8G. International Benchmarks
   - 8H. Reliability of Passive Systems
   - 8I. Post-Fukushima Thermal Hydraulic Research
   - 8J. Integrated Energy Systems
   - 8K. Decommissioning
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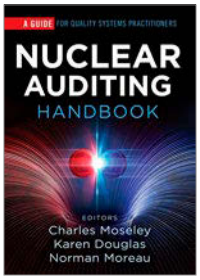
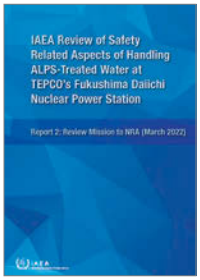
   - 8M. Memorial Session in Honor of Prof. Peter Griffith

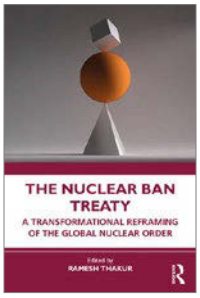
Recently Published



Nuclear Auditing Handbook: A Guide for Quality Systems Practitioners, edited by Charles Moseley, Karen Douglas, and Norman Moreau. Developed as a tool to train lead auditors of nuclear quality systems, this book is also a fine reference for quality managers who plan the audits. In this new edition, the authors provide detailed material regarding the development, administration, planning, preparation, performance, and reporting of quality system audits in energy-related fields. Expanded and made current to today's best practices, the *Nuclear Auditing Handbook* has updated information about requirements and standards and also includes helpful tools to aid nuclear auditors, such as case studies, blank forms, and samples of completed forms. (464 pages, paperback, $150.00, ISBN 978-1-63694-007-6, American Society for Quality; order at asq.org/quality-press)



IAEA Review of Safety Related Aspects of Handling ALPS-Treated Water at TEPCO's Fukushima Daiichi Nuclear Power Station—Report 2: Review Mission to NRA, published by the International Atomic Energy Agency. In this March 2022 report, a review team of 16 international experts assessed safety-related aspects of the implementation of Japan's policy on the handling of Advanced Liquid Processing System (ALPS)–treated water at the Fukushima Daiichi Nuclear Power Station against the IAEA international safety standards. The report compiles the task force's findings under five topics: the responsibilities and functions of the government, major principles and safety objectives, the authorization process, source monitoring and environmental monitoring, and public consultation and involvement of interested parties. (60 pages, PDF, IAEA; free download at iaea.org/sites/default/files/report-2-review-mission-to-nra.pdf)



The Nuclear Ban Treaty: A Transformational Reframing of the Global Nuclear Order, edited by Ramesh Thakur. Adopted by the United Nations on July 7, 2017, the Treaty on the Prohibition of Nuclear Weapons came into effect on January 22, 2021. For advocates and supporters, this means weapons that were always immoral are now also illegal; but to critics, it represents a profound threat to the stability of the existing global nuclear order, with the Nuclear Non-Proliferation Treaty as the anchor. As the most significant leap in nuclear disarmament in 50 years and a rare case study of successful state–civil society partnership in multilateral diplomacy, the treaty challenges the established order. The book's contributors, leading experts on the ban treaty, take readers on a journey through the treaty's origins and history in what is a vital guide for policymakers and students of nuclear disarmament, arms control, and diplomacy. (272 pages, paperback, $44.95, ISBN 978-1-03-213070-5, Routledge; order at routledge.com)

Atomic Hope: Inside the Pro-Nuclear Movement, written and directed by Frankie Fenton. This documentary, which premiered at the Toronto HotDocs Festival in May, highlights the people who advocate for nuclear energy as the solution to the climate crisis and the challenges they face. Scientists, politicians, leaders of pronuclear organizations, and colorful personalities in the movement all lend their voices to this narrative. Frankie Fenton captures their pride, their passion, and their message while acknowledging the stigma surrounding nuclear energy. (82 minutes, film, Kennedy Films; trailer available at atomichope.ie)

ANS Journals

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.

FUSION SCIENCE AND TECHNOLOGY • AUGUST 2022

Improved Plasma Vertical Position Control on TCV Using Model-Based Optimized Controller Synthesis *F. Pesamosca, F. Felici, S. Coda, C. Galperti, TCV Team*

Grad-Shafranov Equation in Fractal Dimensions *R. A. El-Nabulsi, W. Anukool*

Development of a High-Energy X-Ray Backlighting System for Z-Pinch Experiments *F. N. Si, F. X. Chen, D. Wang*

Neutron Direction Distribution in D-T Plasma *L. Li, Z. Zhao, Y. Ma, Z. Ma, J. Lai, Y. Zhu*

Design and Verification of Calorimeter for CFETR Neutral Beam Injection System Prototype with Negative Ion Source *L. Tao, Y. Xie, C. Hu, Y. Xu, W. Yi, N. Tang*

On the Origin of the Local Hardening Zone on Welded Stainless Clad Steel Plates *R. Ghorbel, A. Ktari, N. Haddar*

NUCLEAR SCIENCE AND ENGINEERING • AUGUST 2022

Deceptive Infusion of Data: A Novel Data Masking Paradigm for High-Valued Systems *A. Sundaram, H. Abdel-Khalik, A. Al Rashdan*

Investigation on the Use of the Monte Carlo Iterative k-Source Scheme for the Study of Neutron Subcritical Multiplication *A. K. Mallick, A. Gupta, U. Kannan*

Symmetry Groups of the Forward Master Equation for Stochastic Neutron Populations *P. F. O'Rourke, S. D. Ramsey, B. A. Temple*

Post-Neutron Mass Yield Distribution in the Epi-Cadmium Neutron-Induced Fission of ^{241}Am *H. Naik, S. P. Dange, W. Jang, R. J. Singh*

Modeling and Simulation of Radioactive Nanomaterials of Pb-U, Pb-Th, and Pb-Co in Water-Filled Containers for Nuclear Security Applications *E. Gharibshahi, M. Alamaniotis*

Enhanced Cooling Characteristics of the Cylindrical Cooling Tube Using the Inserted Helical Wire Coil Based on Finite Element Analysis *L.-M. Jin, S. Wu, T. Li, S. Xue, J.-H. Chen, W.-Q. Zhu*

NUCLEAR TECHNOLOGY • AUGUST 2022

CFD Evaluation of Pressure Change Along Coolant Passages in Sodium-Cooled Fast Reactor with Nek5000 *J. Fang, Y. Yu, H. Yuan, E. Merzari, D. R. Shaver*

Detailed Analysis of the Effects of Spacer Grid and Mixing Vanes on Turbulence in a PWR Subchannel Under DFFB Conditions Based on DNS Data *N. Saini, I. A. Bolotnov*

Interface Tracking Investigation of the Sliding Bubbles Effects on Heat Transfer in the Laminar Regime *K. W. Wong, L. Bures, K. Mikityuk*

Modal Decomposition of the Flow in a Randomly Packed Pebble Bed with Direct Numerical Simulation *M. A. Yildiz, E. Merzari, T. Nguyen, Y. A. Hassan*

Acoustic Analysis of the Effects of Vapor-Liquid Interfacial Morphology on Pool-Boiling Heat Transfer *M. H. Almadih, T. Almudhhi, S. Ebrahim, A. Howell, G. R. Garrett, S. M. Bajorek, F. B. Cheung*

Assessment of Screen-Covered Grooved Sodium Heat Pipes for Microreactor Applications *D. P. Guillen, C. G. Turner*

Sensitivity of SC-HTGR Conduction Cooldown to Reactor Cavity Cooling System Failure *B. Mays, L. Lommers, S. Yoder, F. Shahrokhi*

ATHLET Simulation of PKL I2.2 IB-LOCA Benchmark Test and Quantitative Assessment *H. Xu, A. F. Badea, X. Cheng*

Effective Thermal Conductivity of Typical Composite Plate with Inner Heat Source and Temperature Difference *Z. Liu, Y. Ji, H. Zhang, J. Sun*

What can venture capital bring to nuclear innovators?

Rod Adams

Rod Adams (rod@nucleationcapital.com) is a managing partner for Nucleation Capital and the creator of the *Atomic Insights* online newsletter and the *Atomic Show* podcast.

In 1993, after a decade in the nuclear navy during which time I fell in love with nuclear power, I left the service and founded Adams Atomic Engines (AAE) to develop a small, portable engine powered by fission. Today, AAE would be seen as a venture developing an SMR, but back then, I couldn't find enough investors who understood or believed in my vision.

That was deeply disappointing, but over the next several decades I stayed connected with other innovators who had similar visions. I found great satisfaction interviewing members of the industry through the *Atomic Show* podcast and publishing news about advanced nuclear developments on my website, *Atomic Insights*.

Fast forward, and the world is in a very different place. A few years ago, I was contacted by an investor who saw the potential of advanced nuclear designs to meet the world's needs for a clean energy revolution, and I was thrilled. Even in 2019, there were almost no venture capitalists focusing on what was happening in the nuclear industry—probably because nuclear had never fit the venture capital model, which involves investing in the equity of a growing private venture.

We launched Nucleation Capital in 2021. I'm happy to be able to bring a deep technical understanding of nuclear to help founders develop their product ideas and market strategy and contribute capital that enables these visionaries to fulfill their dreams. Even more than capital, we bring a deep conviction and know that the successful ventures will produce technologies that will enable an increasingly prosperous society and a cleaner environment.

Sharing and supporting nuclear entrepreneurs' visions is a dream come true for me. Giving other investors who also believe in nuclear a way to support and participate in the growth of these next-generation designs is another benefit. Most venture funds raise their capital from big institutions, like pension funds. Nucleation Capital has made room for individual investors to participate, even if they can't write large seven-figure checks.

We're pleased to provide this investment vehicle to people who know enough to want advanced nuclear in their portfolio. As a venture capitalist, I'm energized by the opportunity to help nuclear innovators grow and to reward the backers willing to risk capital to help nuclear energy evolve into the tool humanity needs to solve the most wicked problems we've ever faced.

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