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Why Utilities Need to Care About 5G Rollouts

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Why Utilities Need to Care About 5G Rollouts

EPRI research investigates potential radiofrequency exposure of workers and the public

By Chris Warren

Successful and abundant TV advertising has guaranteed that the average person can recite the purported benefits of 5G mobile networks. Commercials featuring both regular people and celebrities like *Saturday Night Live's* Kate McKinnon and singers Dolly Parton and Miley Cyrus extol how much 5G accelerates the speed of video downloads and minimizes the delay (also known as latency) that occurs after requesting data from a network.

The very name "5G" is meant to convey progress. Indeed, 5G refers to the fifth-generation technology standard for cellular networks—the successor of 3G and 4G. Given the ubiquity of smartphones, it's hardly surprising that wireless network providers are eager to promote the benefits of 5G. For a wide range of reasons, though, the utility industry should also care about the rapid deployment of 5G antennas and other infrastructure.

At one level, a secure and modernized grid depends on robust communications. For example, the grid is integrating larger and larger amounts of distributed energy resources (DER) like solar photovoltaics, wind, and energy storage. As DER deployments accelerate, communications become more critical as a tool to connect utilities, customers, and marketplaces in ways that drive decarbonization and enhance grid reliability and resilience.

5G technology also has the potential to improve the future electric grid by advancing everything from augmented reality to automated drones and vehicles. Some utilities are already exploring implementing private 5G networks to enhance security against cyberattacks and to aid remote monitoring and control of grid assets, such as substations and solar power plants.

CONCERNS ABOUT HEALTH IMPACTS OF 5G

Even if utilities haven't fully strategized how 5G can aid grid modernization and security, they must consider its deployment. One reason: the infrastructure required to support 5G will often be installed on existing grid assets. "Utilities should be thinking about this, and some definitely are, because

some have been mandated to install antennas on transmission towers and distribution poles," said Phung Tran, an EPRI program manager.

Utilities also need to be aware of potential customer and worker exposure to radiofrequency (RF) electromagnetic fields emitted by newly installed 5G equipment and the mobile devices it supports. Concerns over potential health and environmental effects of RF exposure have triggered calls for bans and moratoriums on 5G rollouts as well as debates about the science behind some of the concerns.

Exposure limits for workers and the general public have been set by the International Commission for Non-Ionizing Radiation Protection, the Federal Communications Commission, and IEEE. Compliance with these limits depends in part on the relative locations of the individual and the transmitter.

To better understand typical exposures for workers and those using devices that receive data via 5G networks, EPRI recently conducted a pilot study that combined real-world measurements from 5G base stations in Belgium and developed a methodology for measuring exposures. This research, released in 2022(5G Exposure Measurement Pilot Study, EPRI report 3002021620), sought to better understand the typical user and worker exposures near small cell 5G New Radio base stations. These are low-power base stations installed in locations where utility workers and smartphone and other device users could come in close contact with them while they are operating.

BIG DIFFERENCES WITH 5G AND RESEARCH RESULTS

It's important to understand just how different 5G is from previous 2G, 3G, and 4G systems. One big difference is that, though most of the 5G being installed will be implemented in the same frequency band as the previous systems, some 5G applications may be implemented in the higher-frequency millimeter wave RF band. Less is known about RF exposure levels for millimeter waves, though basic physics has shown that they don't penetrate human skin as much as lower-frequency waves.

Another important difference is that 5G equipment typically provides coverage to smaller geographic areas than previous technologies. As a result, 5G infrastructure can be installed at a lower height on utility poles, and the base stations don't need as much power to transmit data to users. In general, this means that RF exposure should be less from these lower-power base stations than from older networks.

But there are some nuances that make accurate measurements of exposure challenging. For example, some 5G antennas have what are known as beamforming capabilities. "In legacy networks, the base station doesn't 'know' where the user is located: it broadcasts uniformly over the expected coverage area," Tran said. Beamforming capabilities, by contrast, allow power to be directed depending on where a user is located. "This ability for 5G antennas to direct power to facilitate communication makes it hard to assess exposure. It's not as simple as before," Tran said.

To account for those differences, EPRI's research took a different approach than past efforts to measure exposure. Instead of assuming exposure to a uniformly distributed RF field, this study included information about the location of users and non-users of the system. It encompassed a wide range of scenarios, including active users and non-users at different locations and different numbers of active users.

The measurements also accounted for how far someone was from a base station, how high the antennas were installed, and what direction the beam was pointing. "We went through and identified user scenarios and types of users to make measurements more relevant than just maximum theoretical exposures," Tran said. "That is more representative than what has been done in the past."

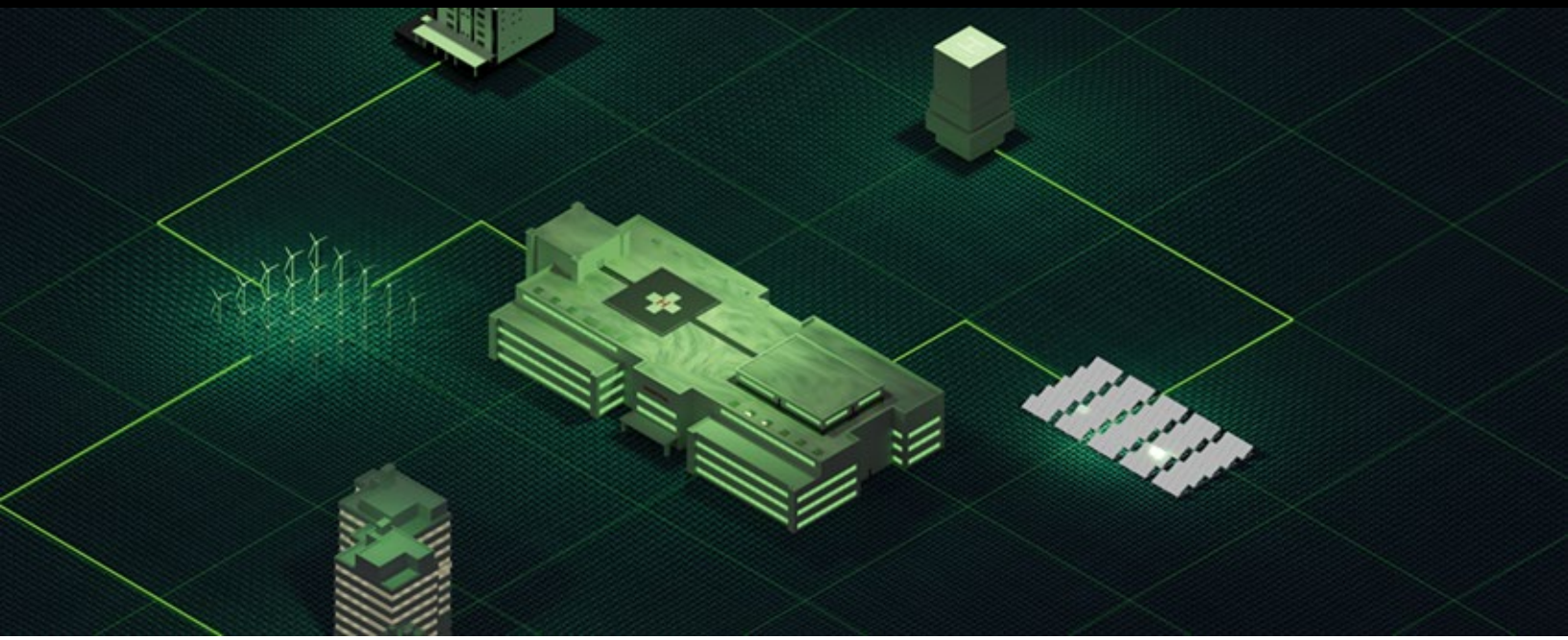
EPRI found that all exposure levels for workers and the public for the two 5G base stations studied were well within established limits. Another finding: 5G antennas with beamforming capabilities produce lower RF exposures.

However, there are limits to these findings and more work to be done. "This is good news for 5G, but we have to caution people that the two systems we took measurements from operate at a lower frequency range that overlaps with an existing 4G system and not in the millimeter wave range," Tran said. "We need to do a separate study to look at the higher frequency range, but we can't do that until we get access to these systems."

Even before that research can be initiated, however, there are ways for utilities to begin using these results. In particular, the findings of this study can help inform how utilities communicate with their employees and provide RF safety awareness training. They can also help answer customers' questions about potential RF exposures from utility-involved 5G deployments.

EPRI TECHNICAL EXPERT

Phung Tran



Improving Human and Climate Health

How new technology aims to lower carbon emissions and improve patient health at UC San Diego Health

By Chris Warren

The healthcare industry is increasingly clear-eyed about the impacts of climate change on its ability to provide patient care and its responsibility to reduce greenhouse gas emissions. An editorial in the *New England Journal of Medicine* labeled climate change "a health emergency," noting that a warming world challenges the work of doctors and nurses in numerous ways—from the need to treat people injured or sickened by extreme weather events to a rise in infectious diseases to the psychological impacts of wildfires, droughts, hurricanes, air pollution, and other negative consequences of climate change.

"Working to rapidly curtail greenhouse gas emissions is now essential to our healing mission," wrote the editorial's authors. The need to decarbonize the healthcare industry is particularly important because hospitals, clinics, medical equipment manufacturers, supplies, and pharmaceuticals are major contributors to greenhouse gas emissions. A study published in *HealthAffairs* found that the U.S. healthcare industry was responsible for 8.5 percent of America's total carbon footprint.

These emissions are also on the upswing. A report released last year by the nonprofit organization Health Care Without Harm noted that the industry's global emissions could triple by 2050 without major changes. Health Care Without Harm is one of numerous organizations—including the National Academy of Medicine and the American College of Physicians—that have formulated aggressive strategies to decarbonize.

There are already numerous tools and technologies that organizations in the healthcare sector can utilize to drive down greenhouse gas emissions. For example, California-based health system Kaiser Permanente announced in 2020 that it had achieved carbon neutrality through measures such as improving energy efficiency and installing on-site renewable energy at its facilities and purchasing carbon-free electricity from external suppliers and carbon credits to offset emissions.

THE NEED FOR INNOVATION

Healthcare decarbonization requires technology innovation to reduce the amount of energy hospitals, and clinics use while still meeting stringent indoor air quality requirements. But emerging and potentially beneficial technologies face a challenge: they must first be vetted and tested in real-world conditions before achieving the scale that will have a significant impact.

One of EPRI's primary roles is to facilitate projects that test and evaluate promising new technologies. "When EPRI gets its hands on emerging technologies, we run field trials and try to validate the technology or the market," said Agatha Kazdan, an EPRI principal technical leader. "We are trying to look at it from the state's and utilities' perspectives to verify how this improves the situation for society, ratepayers, and operation of the grid."

A new project at Jacobs Medical Center at UC San Diego Health aims to confirm the decarbonization and other benefits a promising cooling and dehumidification technology can deliver in a healthcare setting. The project, which is supported by a $1.44 million grant from the California Energy Commission (CEC) and is being implemented and evaluated by EPRI, involves the installation of two high-efficiency dehumidification system (HEDS) air handling units (AHUs) designed by Conservant Systems, Inc. to serve seven operating rooms and the associated support spaces at Jacobs Medical Center.

"The HEDS technology has the potential to decarbonize large commercial buildings, like healthcare facilities, in an energy-efficient way by reducing energy use and greenhouse gas emissions while providing benefits to the electric grid and providing building occupants with a healthy and comfortable environment," said Jonah Steinbuck, director of the Energy Research and Development Division at the CEC.

THE IMPORTANCE OF AIR QUALITY AT HEALTHCARE FACILITIES

One driver of interest in HEDS technology is its potential to address both current and future challenges faced by healthcare heating, ventilation, and air conditioning (HVAC) systems. An increasing concern is how to properly control relative humidity as the world becomes warmer and wetter.

Many of the HVAC systems used in healthcare facilities today were designed and built 20 to 40 years ago. "They were never designed to work with today's outdoor conditions," EPRI's Kazdan said. "Equipment wear and performance degradation can also create conditions that promote the growth and spread of biological pathogens and healthcare-associated infections (HAIs)."

HEDS can both cool and dehumidify buildings while also filtering the air to reduce the spread of biological pathogens and viruses like COVID-19. The systems will replace UC San Diego Health's existing AHUs, which rely on chillers and boilers powered by both electricity and natural gas to control the temperature and relative humidity of indoor environments. Replacing the existing AHUs with significantly more efficient HEDS is expected to reduce the energy consumption required by boilers and chillers. In non-healthcare Department of Defense (DoD) and federal laboratory applications, the HEDS technology has been shown to reduce the cooling and heating loads for temperature control and dehumidification by over 50 percent and requires very little maintenance.

The potential of the new HEDS units to simultaneously lower emissions and costs while ensuring operating rooms maintain the optimal temperature and relative humidity was an important driver of the project. "In operating rooms, the surgeons and patients are in a critical state during surgery," Kazdan said. "The value proposition was energy savings and reducing operating costs and emissions. But it's also improving the system's performance to benefit patients and medical staff."

Securing benefits for patients was a big reason Joe Dizon, energy manager at UC San Diego Health, was eager to implement the HEDS AHUs. "Humidity and temperature control in operating rooms is critical to patient safety, which is our first priority," Dizon said. "The new units will better serve our facilities by improving the air quality. This, in turn, supports a safer environment for patients and does so more efficiently. Being able to both increase patient safety and decrease energy usage directly aligns with the goals of our organization."

PART OF A LARGER DECARBONIZATION EFFORT

It's also important to keep in mind the broader context surrounding this project, particularly as it relates to decarbonization. California recently passed legislation to achieve 90 percent zero-carbon electricity by the end of 2035 as part of the state's commitment to achieving economy-wide net-zero emissions by 2045.

The University of California also has ambitious climate and energy goals. For example, the UC system as a whole has pledged to use 100 percent clean electricity by 2025 and achieve Scope 1 and Scope 2 climate neutrality in the same year. In addition, UC campuses and health facilities have targeted a 2 percent annual reduction in energy use intensity. The UC system's multibillion-dollar endowment and pension funds have also divested all fossil fuel investments and have financed over 1.7 gigawatts of wind, solar, and battery storage installations around the globe.

UC San Diego Health engages staff, faculty, and leadership across the health system to increase sustainable behaviors that contribute to emissions reductions and community health. Planning efforts are underway to redevelop the system's medical center in Hillcrest, and construction has begun on a new outpatient pavilion that is designed to reduce carbon intensity by over 90 percent.

Green certification programs for medical clinics, units, and offices provide standardized methods to evaluate, enhance, and recognize sustainable work behaviors and practices. Efforts to improve the sustainability of UC San Diego Health operating rooms have focused on reducing waste, reducing the impacts of anesthetic gas, and improving energy power-down strategies. Procurement strategies have vastly increased the use of energy-efficient electronics and reprocessed single-use devices in trauma operating rooms, which has yielded annual savings of over $800,000 and eliminated nearly 14,000 pounds of waste.

The medical center hosted an initial two-part Climate Resiliency Workshop in partnership with the UC San Diego academic campus. UC San Diego Health is the only medical center in the San Diego region that has joined the UN Race to Zero climate commitment.

HOW HEDS WORK

Grasping how HEDS work is necessary to understand how a change in the technology used to cool and dehumidify buildings can potentially achieve substantial cost and emissions reductions. At a very basic level, all AHUs are outfitted with heat transfer coils that have hot and cold water running through them. Fans move air across the units, and cold or hot coils cool or heat the air, depending on the needs of the building occupants.

Most AHUs use a lot of energy to do their job. "In most buildings across America, they have what's called a cooling coil in the unit, and then they have a reheat coil that is above the space where you're doing your work in the room," said Chris Roman, director of business development at Conservant Systems, the inventor of HEDS and a partner in the UC San Diego Health project. "If it's an operating room and you're a surgeon doing open heart surgery, there's a coil above your head that heats the space to control relative humidity. It works, but it's a very, very energy-intensive process."

A big reason traditional AHUs are so energy intensive is that the cooling and reheating coils have separate energy sources. A chiller powers the cooling coil, and a natural gas boiler creates hot water for the reheat coil.

By contrast, with HEDS, a chiller alone can provide energy to both cooling and reheat coils and meet most of the reheat needs. The reason: the coils in HEDS are designed to capture heat generated during cooling and dehumidification and repurpose that heat rather than wasting it. The reheat coil is supplied with energy already produced, which significantly improves efficiency.

"We reheat the air with the energy we've already paid for. So, during surgery, that causes the reheat coil to open very minimally," Roman said. "The more that reheat coil stays closed, the more load you are removing and the more you are decarbonizing the facility."

HOW HEDS SAVES ENERGY

TYPICAL AIR HANDLING UNIT (AHU)

1 Belt-driven supply fan(s) feed air at a high velocity into the AHU, wasting fan and chiller plant energy.

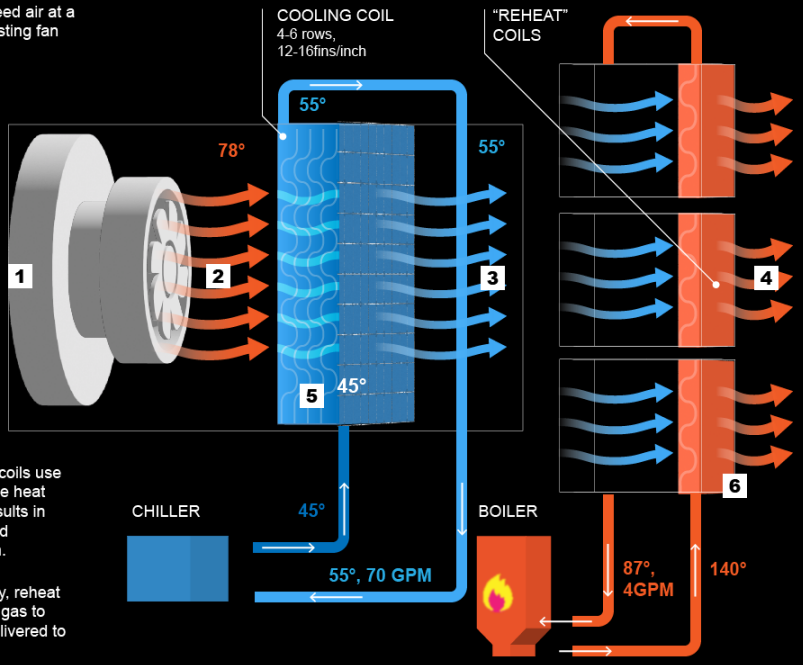
2 Hot, wet air is blown into the cooling coil where heat is removed, and moisture is condensed out of the air.

3 Cold air at near 100% relative humidity leaves the cooling coil and must be reheated to control temperature and relative humidity (RH).

4 The cold, high RH air is reheated, using a new heating energy source for the process or comfort conditioning. Low RH air is required to reduce mold and corrosion issues.

5 High-face velocity cooling coils use small surface areas that reduce heat transfer effectiveness. This results in higher fan, chiller, pumping and fossil-fuel energy consumption.

6 Small, very high air velocity, reheat coils use considerable natural gas to reheat the supply air that is delivered to the zones. This is a very carbon-intensive process.



DECARBONIZED HIGH EFFICIENCY DEHUMIDIFICATION SYSTEM (HEDS) AHU

1 High efficiency direct-drive electronically commutated motor fan arrays feed air at a low velocity into the AHU, saving fan and chiller plant energy.

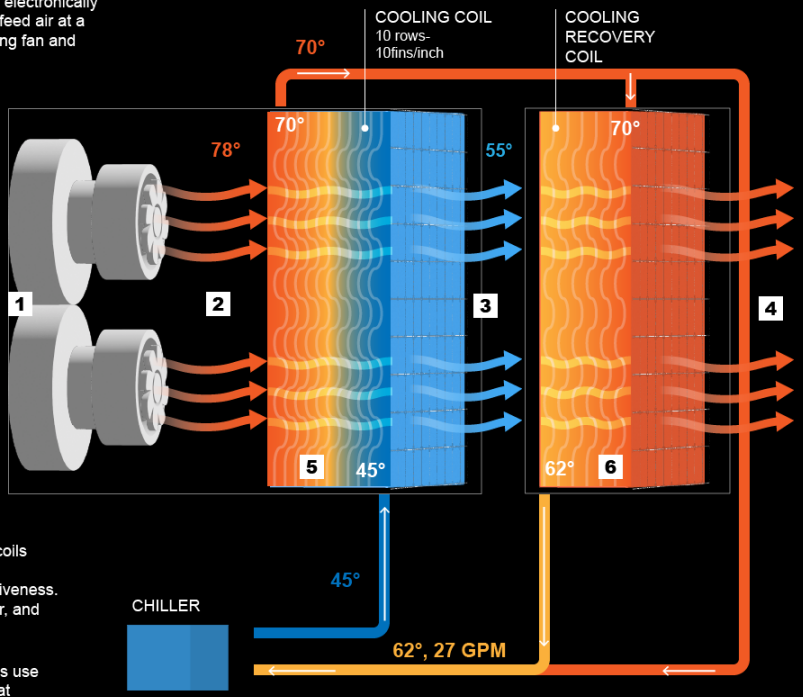
2 Hot, wet air is blown into the cooling coil where heat is removed, and moisture is condensed out of the air.

3 Cold air at near 100% relative humidity leaves the cooling coil and must be reheated to control temperature and relative humidity.

4 The cold, high RH air is reheated by passing the air over the cooling recovery coil using recycled energy captured from the chilled water return line. This reduces the loads on the boiler and chiller plants, helping to decarbonize the HVAC process.

5 Low-face velocity cooling coils provide high surface area that maximizes heat transfer effectiveness. This results in lower fan, chiller, and pumping energy consumption.

6 Low air velocity reheat coils use recovered energy for the reheat process, reducing or eliminating fossil fuel use for the HVAC system.



POTENTIAL STATEWIDE IMPACT

HEDS can potentially deliver significant benefits to healthcare facilities across California and the world. EPRI estimated the cost, greenhouse gas emissions, peak load, and water savings benefits that could result if HEDS were used to cool and dehumidify California's 112 million square feet of healthcare facilities.

For example, EPRI calculated that wide-scale deployment of HEDS could reduce the cooling load at California healthcare facilities by 24 percent and lower annual cooling costs by $26.2 million. HEDS could also significantly reduce peak load, which is particularly important in California, given the strain on the grid due to extreme heat.

Considering the ambitious decarbonization objectives of the state and the university system, the greenhouse gas emissions reductions HEDS can provide are a priority. The emissions reductions result from both improving cooling efficiency and eliminating the use of natural gas for reheating. EPRI estimates that the improved cooling efficiency HEDS provides could reduce CO2 emissions for commercial customers in the state by nearly 800,000 tons.

Eliminating the need for natural gas to fuel reheating in traditional AHUs could reduce commercial reheating emissions reductions of more than four million tons. EPRI also calculated that HEDS technology has a 30 percent lower water evaporation rate than typical AHUs, an important benefit in the drought-stricken state.

IMPLEMENTATION INFORMED BY A TRACK RECORD

The implementation of HEDS at UC San Diego Health is an important step in demonstrating and verifying its benefits in a demanding healthcare setting. In turn, this project rests on successful operation of HEDS in other environments since 2016.

The technology was originally developed for the DoD, whose main priorities were maintaining air quality in its facilities and utilizing cooling and dehumidification systems that required little maintenance. "The DoD has very limited maintenance budgets and staffing, so the HEDS was designed to be the lowest lifecycle cost available, with very limited maintenance requirements," said Scot Duncan, president of Conservant.

Photo courtesy of University of California San Diego Health

As Conservant refined the design, it worked with the U.S. Army and Navy on Guam. "We learned so much about what works and does not work on Guam, and we have upgraded HEDS components to live in that harsh climate so that HEDS can operate in less stressful environments for a long time," Duncan said.

HEDS have since been used at U.S. Navy, Air Force, and Army facilities, as well as at a government laboratory in San Juan, Puerto Rico. HEDS have performed well enough that the DoD recommended expanded use of the technology in its 2019 *High Performance and Sustainable Buildings Report to Congress*. HEDs were also implemented at the Naval Weapons Station in Seal Beach, California—a project recognized with a 2021 Secretary of the Navy Energy Award in the Technology Development category. HEDS is also being piloted by the U.S. General Services Administration (GSA) as part of an initiative to test and validate building decarbonization technologies.

More recently, HEDS technology was incorporated into a renovation of the Timken Museum in San Diego, with the goal of delivering 99.99 percent purified air and, ultimately, fully electrifying and decarbonizing the HVAC system.

The design phase of the UC San Diego Health project is now complete, and construction is expected to begin by 2024. Once the two HEDS units are finished, EPRI will monitor their performance for a minimum of nine months.

"If the HEDS technology affects healthcare in the same manner that it has worked for the DoD, the federal lab, and the Timken Museum, it could be a game changer from an energy, decarbonization, and HAI-reduction perspective," Duncan said.

EPRI TECHNICAL EXPERT

Agatha Kazdan

Elevating Energy Literacy in Nigeria

How EPRI volunteers are helping prepare future leaders to make complex energy decisions

By Chris Warren

With the sound of honking cars in the background, a progression of Nigerian students explained to the camera how they believe the city of Kano can develop a reliable electricity supply by 2050.

Their presentation's title, "Energy Is Life," is more an aspiration than a reality in Nigeria. Indeed, according to the World Bank, 43 percent of Nigeria's 217 million people lack access to grid electricity. The students are clear-eyed about some of the challenges they face in devising an electrification strategy for Kano. According to them, these include a lack of water, wildfire risk, and a generally poor local economy. Further, while access to energy is sketchy today, the need for electricity will only grow as Kano's population of 4.3 million more than doubles by 2050.

But the students who appeared in the video have put a lot of thought into these challenges and have come up with solutions to deliver the steady supply of electricity that all thriving economies and societies require. The students' 2050 plan for Kano includes a mix of several energy sources, balancing availability and flexibility.

The presentation was one of 18 developed by young people from schools around Nigeria for a "Think Critically About Energy" competition. The competition stemmed from an energy literacy workshop led by Mary Presley and Maria Guimaraes, who both work in EPRI's Nuclear Sector, along with Dr. Caroline Obiageli Emeka-Ogbonna, who directs the Centre for Critical Thinking, Teaching and Learning at the Nigerian Defence Academy.

Held this past August in Nigeria's capital city of Abuja, the two-day energy literacy workshop was delivered to 53 teachers from 18 Nigerian secondary schools. The teachers returned to their schools and presented the same curriculum to their students. Many of those students then submitted video and written presentations explaining their proposals for a 2050 energy mix able to meet the needs of the region.

EPRI EXPERTISE TRANSLATED TO A PRACTICAL GUIDE FOR UNDERSTANDING ENERGY DECISIONS

The roots of the workshop in Abuja, which was sponsored by the U.S. State Department, can be traced back a decade. Using work that EPRI's Technology Innovation (TI) program first produced in 2011, Presley and Guimaraes developed a curriculum and activity to teach high school students about the range of issues to consider when developing an energy portfolio. The course, which has been taught in schools in the Charlotte area, draws heavily from EPRI's expertise and includes both foundational instruction and exercises to apply concepts and knowledge. The curriculum has been updated to reflect changes to the energy landscape and encourages students to factor in possible future innovations that may impact energy portfolios.

EPRI is in a natural position to provide this sort of instruction. With deep expertise in the technologies, economics, and policies that shape energy systems and a mission to serve society, EPRI is committed to educating the public as an important part of its ongoing work.

The knowledge EPRI can deliver to young people is particularly important because of the rapid changes and innovations transforming the energy landscape. As energy systems change and evolve, the sort of information EPRI can provide about technology advancements, limitations, and interoperability will be an important foundation for high school students who will soon have to adapt or invent new technologies and solutions.

The workshop in Abuja started that work with instructions and activities about:

- **Basic energy and electricity concepts.** Most people don't know that the vast majority of electricity is generated by spinning turbines or the difference between power and energy. Grasping elemental terms and measurements like capacity factor and megawatt-hour helps provide a foundation for understanding energy options and strategies.
- **Generation types.** Developing an energy mix to meet the needs of Nigeria in 2050 means understanding available options, from solar and wind to hydro and geothermal to coal, natural gas, and nuclear. This course component provided a primer on how these technologies work, their benefits and challenges, and their availability in Nigeria. It also discussed emerging technologies such as carbon capture and storage, small modular nuclear reactors, and others.

- **Decision-making criteria.** Using the EPRI-developed Generation Technology Reference Card, this course module explored the factors to consider in choosing generation technologies. These range from construction and electricity costs to land use and greenhouse gas emissions to availability and flexibility. This part also introduced the concept of innovation to offset existing technologies' limitations.
- **Decision-making exercise.** Teachers were tasked with designing 2000-megawatt energy systems for countries with varying constraints and resources. For example, some were asked to come up with an energy mix for a densely populated island nation in a seismically active region with scant supplies of natural gas and coal and a law requiring that half of its energy come from emissions-free sources. The groups then presented their energy mixes to the entire class.
- **Nigeria 2050 competition.** The final module of the workshop prepared teachers to return home and deliver the same course to their students. The students were then encouraged to participate in a competition to design a fully functional 2050 energy system for their town or region.

While basic knowledge about energy and electricity and decision-making skills were essential components of the curriculum, training in critical thinking was woven throughout the entire program. The ability to evaluate information sources, ask questions, and properly frame complex problems is always important. But it will be especially vital for young people to apply critical thinking to decisions about rapidly evolving energy technologies and their role in unique geographies, cultures, and economies.

EDUCATING STUDENTS WHO WILL MAKE IMPORTANT DECISIONS

Nigeria faces daunting energy challenges. Not only do millions of Nigerians lack access to electricity, but the population of the country is also growing rapidly. By 2050, Nigeria will be the third most populated country on the planet. To meet the energy demand of its people, Nigeria must dramatically expand its current 12,000 megawatts of power generation.

Today, about 80 percent of electricity in Nigeria is produced by burning fossil fuels. The country has pledged to achieve net-zero emissions between 2050 and 2070. Nigerians have many difficult questions to answer and solutions to develop to balance the growing need for energy and the imperative to decarbonize. These will require young people to develop a deep understanding of energy technologies and the mindset and skills to make complex decisions. "The people who will solve these challenges are in high school today," said Guimaraes, who is a program manager at EPRI. "We need to train kids in high school because they will be the ones making decisions leading to 2060."

While the building blocks of the curriculum Presley and Guimaraes presented were well established, several adjustments were needed to make it more impactful and relevant in Nigeria. For one thing, the course targeted teachers rather than students because training instructors ultimately means more students will be exposed to the material. "We made a concerted effort to train teachers and give them the curriculum in detail so they would know what to teach their students," said Presley, who is an EPRI technical executive.

Some of the specific course material also had to be tweaked. For instance, Presley and Guimaraes scrapped using a country with a cold climate in the decision-making exercise. "The first time we showed everything to our colleague in Nigeria, she asked why we had a picture with snow. They never have snow," Presley said.

Integrating cultural issues into the workshop was also important. In the United States, discussions about the evolving energy mix tend to focus on technology. "We engaged science and civics teachers, and that was important because people recognize that this is not just a technology problem," Guimaraes said. "In the teacher discussions, it became clear that there are cultural changes that need to be made to get where Nigeria needs to be, and civics and critical thinking came out as much as science."

While Presley and Guimaraes made plenty of adjustments to make the curriculum and activities resonate with the Nigerian teachers, they still exposed them to novel instructional approaches. For instance, working in small groups and making presentations are not common. But the teachers responded well to both. "They were excited and made posters and did their presentations. It was a totally different energy when they did that, and they debated among each other, and one thing that came out was that you can be critical without criticizing," Presley said.

CONTINUING THE WORK

A single workshop and student competition is obviously not enough to prepare young Nigerians to make important energy decisions in the future. Even as Presley and Guimaraes were seeking funding for the workshop and preparing the curriculum, they were also considering how to make this instruction sustainable over the long term.

One step is to leverage local energy experts in Nigeria to work more closely with teachers. "We got a lot of support from the World Energy Council and the Nigerian Energy Commission, and that was a nice thing for teachers to see it wasn't just U.S. experts, but also local folks high up in energy," Guimaraes said. "We made an effort to make sure it didn't seem like we were telling them how to do things. We were

giving them information, but they are the experts on their own lives, and having local experts engage teachers can help keep this going and give it legitimacy."

What was apparent throughout the workshop was just how hungry the teachers were for knowledge. In two-day workshops, it's common for attendees to gradually lose focus and interest. "We had fully engaged people absorbing everything. The thirst for this information is very strong," Presley said.

EPRI TECHNICAL EXPERTS

Mary Presley, Maria Guimaraes

A Magic Kingdom for Pollinators

How Disney uses its commitment to solar energy to expand habitat for pollinators

By Chris Warren

Sustainability-minded visitors to Walt Disney World's EPCOT in Florida may well find themselves lingering outside the entrance of the 305-acre attraction theme park. That's because a 22-acre swath of land just outside the park is home to a 48,000-panel, 5-megawatt (MW) solar power plant in the shape of Mickey Mouse's head.

It's appropriate that EPCOT is the site of such a conspicuous and memorable solar power plant. Conceived by Walt Disney himself, EPCOT originally stood for *Experimental Prototype Community of Tomorrow*, and its attractions celebrate the magic of possibility through technological innovations and humanity's capacity to forge a better future together. But the solar plant is by no means ornamental. Along with the much-larger, 270-acre, and 57 MW Citrus Ridge Solar facility (also known as *FL Solar 5*) nearby, solar now provides enough renewable electricity to operate two of the four Disney theme parks in Orlando.

The solar projects were developed with partners Duke Energy, Origis Energy, Reedy Creek Energy Services, and Reedy Creek Improvement District as part of the company's sustainability and decarbonization goals. By 2030, the Walt Disney Company has pledged to produce or purchase zero-carbon electricity to power all its direct operations. In 2020, Disney achieved a 50 percent reduction in net emissions compared to 2012 levels.

Anyone encountering the Mickey-shaped solar array on their way into EPCOT should keep in mind that Disney is a storytelling company; there are always layers and nuances to what may otherwise seem like an obvious tale. In this case, Disney's commitment to solar energy is also a story about innovative efforts to provide vital habitat to Florida pollinators. "We recognize that renewable energy is amazing. But it takes up a lot of space," said Morgan Belle, who has helped spearhead Disney's effort to pair solar and pollinator habitats. "It was a natural progression to figure out what we could do with this land in addition to having it as a solar facility. There's all this valuable land underneath and around the panels, so we might as well figure out how to use that, too."

That has translated into 160-plus acres of pollinator habitat and 10 acres of research meadow that includes 18 species of grasses and forbs, including Birdsfoot Trefoil, Blackeyed Susans, and Purple Lovegrass. About two-thirds of the species are native to Florida. The mix of grasses and forbs was selected partly because they bloom at different times throughout the year to support pollinators like bees, butterflies, birds, bats, and some insects.

AN AWARD-WINNING PROJECT

In November, Disney was awarded the EPRI & North American Pollinator Protection Campaign's (NAPPC) Pollinator Electric Power Award for its success in co-locating solar and pollinator habitat. Founded in 1997, NAPPC runs a host of programs in North America and across the world with the mission of promoting pollinator health. The non-profit organization gives awards to honor the accomplishments of pollinator advocates, farmers and ranchers, and transportation agencies that promote the expansion of roadside pollinator habitat.

In 2020, EPRI's Jessica Fox helped brainstorm how NAPPC could add a unique recognition to its annual award program that would acknowledge projects working at the intersection of electric power and pollinators. Soon after, EPRI and NAPPC launched the award category. The inaugural award went to American Electric Power (AEP) for researching the pollinator benefits of planting native prairie grasses and flowers instead of traditional grasses along transmission line corridors. Last year's winner was the Toronto and Region Conservation Authority (TRCA), which was recognized for an urban restoration project creating a so-called "Meadoway" connecting seven rivers and ravine systems, 15 parks, 16 kilometers of trails, and 13 neighborhoods with over 200 hectares of green space populated by 1,000 species of flora and fauna. In October 2022, Disney accepted the award during the annual NAPPC meeting in Washington, D.C.

Winners of the award are thoroughly vetted by a panel of scientists who are primarily seeking to answer one fundamental question: Is the project having an important benefit to pollinators? "Disney

Photo courtesy Disney Conservation

received the Electric Power Pollinator Award because their project was backed by impressive ecological outcomes and public education, both things that the independent scientific review committee considers," said Jessica Fox, a member of NAPPC and a senior technical executive at EPRI who leads the organization's Power-in-Pollinators initiative.

The review process is rigorous, and competition for the award is increasingly fierce. The review committee considers award applications by asking specific questions to determine the tangible benefits pollinators receive. "The committee looks at the region where the project is located and asks what species were planted to determine whether it's a native mix able to bloom over multiple seasons," Fox said. "People on the committee are botanists, entomologists, and restoration ecologists, so they understand if legitimate pollinator conservation protection is occurring." The award committee also reviews the applicant's success in communicating the value and importance of pollinator protection and the commitment to keep a project up and running over the long term.

BUILDING ON A LEGACY OF CONSERVATION

Heading into this project, Disney had the advantage of years of experience with pollinator habitat. The company has maintained pollinator gardens at its parks and resorts and has long conducted butterfly surveys in its conservation areas. "We have pollinator programs across our parks and resorts where guests and cast members (employees) can come and actually learn how to survey these gardens and gather data," Belle said.

In selecting the species to plant under the solar arrays, Belle and her colleagues wanted to ensure that there was a range of blooming times, that the plants were drought tolerant and commercially available, and that the species didn't grow to heights that would shade the panels. "We started with a species list that we tend to use in our ornamental gardens in our theme parks and resorts, where families have helped us with community science," Belle said. "That helped us determine which plants receive the most visits from pollinators. So, families visiting the theme parks helped influence which plants we initially selected."

In 2018, Disney planted 68 two-by-two-meter test plots to better understand different species before opting to go under and around the solar arrays. "There's not a lot of information about solar pollinator habitat in our region," Belle said. "We wanted to start small and prove that it works well before scaling up." In the years since, Disney has scaled up its planting of pollinator habitat. Vegetation management involves mowing one to three times per year, depending on the location, and is handled by the energy companies operating the power plants.

The fact that Disney owns the land and leases it to the energy companies that run the solar arrays is an indication of the influence that large corporate purchasers of clean energy can have on project details—including whether they provide pollinator habitat. "As a large customer, corporations can say, 'This is the type of power that we want,'" Fox said. "With the idea of end-to-end sustainability, one of the huge drivers is that large customers like Disney can say to the power company, 'This is what we want; can we work together and figure out how to do it?'"

This was exactly the attitude Duke Energy brought to the project. "The credit goes to Disney in this," said Will Ricks, senior environmental scientist at Duke. To Ricks, Duke's task was to collaborate closely with

Disney to accomplish the necessary engineering and project planning to come up with the array designs that could accommodate pollinator habitat.

Ricks notes that local knowledge of Florida weather, soil, and plants was essential to the project's success. He's also certain that Disney's success will be a catalyst for more habitat conservation. "What's key for pollinators and solar moving forward are success stories, and I can't think of a better or more successful story of pollinators and solar than Disney," said Ricks, who has personal experience establishing pollinator habitat on his family's farm in North Carolina. "It can be challenging, but it takes folks like Disney to put those puzzle pieces together."

Origis Energy's involvement in the Disney project is part of the company's ongoing efforts to conserve pollinator habitat. "We are very proud that Disney selected the Citrus Ridge project to host its innovative pollinator conservation efforts and studies," said Jason Thomas, a project developer with Florida-based Origis Energy. "This is a perfect fit with Origis's pollinator program."

Ultimately, the project's goal is to provide carbon-free energy and genuine benefits to pollinators. In that regard, it has been a success. So far, over 40 native species of pollinators and at least 60 species of insects have been making use of the solar pollinator habitat. "We're finding more pollinators are making use of our solar gardens in comparison to the standard turf grass sites, and we compare these results to a conservation management area we monitor," said Belle, who is working on a peer-reviewed publication to share the results.

One of the factors considered in the award review is future plans for the pollinator sites. To that end, Disney is going to continue adding more habitat in and around the solar arrays and is initiating several research projects as well. Among the things Disney wants to study are best management practices to maintain the habitat, how the microclimate under the arrays impacts flowering phenology and abundance, and the solar habitat's effect on native bees.

Photo courtesy Disney Conservation

As a storytelling company, Disney has also proactively shared what it learned throughout the project with the public, the scientific community, and its employees. "We are always pleased to share this story as part of our collective efforts through what we call *Disney Planet Possible*," Belle said. "As we look to the future, we are committed to taking action to put possibility into practice and inspire optimism for a brighter, more sustainable future."

EPRI TECHNICAL EXPERT

Jessica Fox

A Culture Shift in Nuclear Power

How a culture of innovation can help nuclear power play a major role in the transition to a decarbonized world

By Chris Warren

Wynter McGruder has been to enough nuclear power industry conferences to know what to expect. Inevitably, she says, a succession of smart engineers will stand up and deliver scripted and formal presentations about weighty matters, such as advances in reactor design and materials science.

It's what the audience demands. "You always have an audience of technical people who have spent their careers deeply focused on serious work," said McGruder, an EPRI principal technical leader in the nuclear sector who previously spent about a decade as a reactor pressure vessel engineer for the utility Xcel Energy.

In other words, nuclear conferences can be counted on to feature serious people talking about serious topics. To put it mildly, last summer's Global Forum for Nuclear Innovation (GFNI) in London did not follow that familiar script. At the event's kickoff, a stage was set up with a speaker's rostrum and a grouping of chairs suitable for roundtable discussions. But into that familiar setting strode Jon Chase. Clutching a microphone and casually dressed, Chase walked right past the rostrum and began to rap.

"There's a crisis with the climate that's affecting the globe, and we're looking for solutions that are ready to go, but as you know, they take a little time to evolve, so let's grow and innovate until the problem is solved," Chase began. "We've gotta be bold, become the agents of change, and think about the four behaviors that we can arrange. It starts with you, so let's keep the target in view and gather all our energies to make the future nu-cleeeeeaaaar."

Later, Chase initiated a call and response with the audience, asking them, “are you clear, nuclear?” and then encouraged attendees to answer, “what we’re here to do!” Those who paid close attention to Chase’s lighthearted lyrics, though, couldn’t miss the seriousness of the message. In short, Chase told his audience that the world desperately needs nuclear power to address the climate crisis. But also layered into the lyrics were reminders that those assembled in the room had to do things differently than they had in the past.

Indeed, in just a few words, Chase illustrated the balance that must be struck for nuclear to play the role it can in building a decarbonized future. “So, on the one hand, there is safety. On the other is innovation. One relies on caution and the other inspiration, but the two must function hand in hand for any operation to succeed,” he sang. “How to find the balance is the vital question. We need the brightest minds, but we have to build them first through an education system that is thriving and diverse, then attract them to the sector and make room for them to grow, so they broaden the perspective and challenge the status quo.”

A GROWING RECOGNITION OF THE NEED FOR CHANGE

To be sure, discussions about the need for innovation in nuclear are nothing new. In fact, at the 2019 GFNI in South Korea, the first day of the conference was devoted to learning about what drives innovation outside the nuclear industry, including lessons from astronauts and the researchers behind breakthrough pharmaceuticals. The gathering also featured feedback from nuclear industry regulators, who emphasized their strong desire to collaborate on innovation.

An important insight that crystallized at the 2019 GFNI was that past efforts around innovation had been too focused on technology and not enough on building the kind of industry culture that breeds consistent and transformative innovation. The 2019 GFNI identified four essential behaviors needed to foster an innovative culture: courage, a challenger mindset, diversity, and role modeling.

While important, the mindset shift that occurred in South Korea four years ago was about building momentum to shift the day-to-day behaviors that constitute culture. What Chase’s rap and other activities at the GFNI in London did was to move beyond theoretical discussions of innovation into the often uncomfortable and messy reality of thinking, acting, and collaborating in new and innovative ways.

EMBRACING AND CULTIVATING THE DISCOMFORT OF INNOVATION

McGruder felt that discomfort acutely at first. “I have crippling second-hand embarrassment,” McGruder recalled with a laugh. “When the rap started, I didn’t want to see it. But it ended up loosening things up, and it was fun, demonstrating that it is OK to think outside the box.” Subsequent activities illustrated some of the mental barriers that prevent innovation. For example, Emma Wong, an EPRI technology and innovation advisor to the Organization of Economic Cooperation and Development (OECD), led an activity illustrating the importance of questioning status quo beliefs.

The activity was a competition to build a sailboat car using a few simple materials (like paper and a paper towel roll) and see which one could speed across a table fastest. But the instructions and example participants were given subtly introduced limitations on innovation. “We introduced bias by calling it a car and showing an example that had four wheels and a sail on a boat,” said Sam Johnson, a senior project manager at EPRI, who attended the GFNI. “And everyone made slight variations of the car. Nobody challenged what could make it better. And that was the point. Pre-conceived notions, biases, and terminology can hinder our creativity in solving the problem at hand. The main problem is mindset.”

Of course, even the most innovative GFNI conference is just one step towards driving genuine change in the culture of the entire nuclear industry. What's important is that the ideas and behaviors unveiled and modeled at these infrequent gatherings are then shared, reinforced, questioned, and evolved at institutions across the entire industry.

UNDERSTANDING BARRIERS TO INNOVATION

Driving the changes in mindset that will result in meaningful and consistent innovation also requires being clear-eyed about some of the real and understandable barriers that have prevented it in the past. "To understand innovation in nuclear, you have to think about the nature of the nuclear industry," McGruder said. "It has thrived and been safest when it is highly procedural. It's not just about highly trained people. It also is highly rules-driven. That does not facilitate much room for risk-taking and innovation."

McGruder says that most innovation in nuclear in the past has been technology focused and incremental. For example, she points to the decade-plus the industry took to transition from paper-based work packages to digital. Another example: The reluctance to embrace 3D printing to produce complicated design parts used in reactors. "3D printing was in existence and required less welding and was safer, but it was hard to get people on board because it was a new technology," McGruder said. "The industry was excited by the technology, but because parts are such an important part of a plant's safety strategy, you have to be so cautious that any change is going to be safe."

But both McGruder and Johnson say there are plenty of signs that the industry is serious about fostering an innovative culture. For example, Johnson says many more utilities have initiated innovation programs with dedicated staff and budgets in recent years. This helps keep innovation at the top of a utility's priority list. "Innovation can be a low priority when you have 10 things to do each day," Johnson said. "Having a dedicated staff and a forum for communicating what you're learning matters."

The nuclear industry has a unique opportunity to shift its culture to become more innovative. Like the rest of the utility industry, large numbers of seasoned nuclear employees are either in retirement or nearing the end of their careers. Newer employees, many of whom are attracted to nuclear because of the big role it can play in the transition to a decarbonized power system, are eager to contribute new thinking.

"Innovation has been grassroots in the industry over the past few years. A lot of early career folks are willing to speak up and say, 'I have a good idea,'" McGruder said. "And leadership in organizations increasingly see the value in innovation and what it can do in other industries and are letting people run with ideas and funding them. That wouldn't have happened 10 or 15 years ago."

CONTINUING THE PUSH TO INNOVATE

EPRI is also focused on cultivating an innovative culture among nuclear sector researchers and helping member utilities as they work to become more innovative. For example, in January 2021, EPRI launched the Nuclear Innovation Working Group. The group's mission is to create a community of nuclear innovation leaders to build support, coordination, and awareness of the industry's past, current, and future innovations and technologies. The group, which meets twice annually, has discussed a range of topics, including drones, submersibles, machine learning, robotics, digital twins, advanced manufacturing, and artificial intelligence (AI).

Coming out of the London GFNI, EPRI staff are also leading ongoing research and collaboration around four Grand Challenges. The industry has identified these areas as important to cultivating innovative cultures and mindsets. The Grand Challenges are:

- **Think Tank: No talent, no sector**—The nuclear industry must recruit and retain talented and innovative people to thrive in the future. This work will look at the actions the industry can take to ensure it has both enough talent and the right type of talent.
- **Brain Bubble: Operating a lean machine**—Lean operation is nothing new in the nuclear industry. However, building on past successes remains important, and this initiative will take a close look at efficient operations and modernization.

- **Energy Pod: Safe doesn't have to be slow**—Safety will always be the number one priority in nuclear. The work around this challenge will examine how safety can remain the top priority while still cultivating rapid and disruptive innovation.
- **Power Hub: Beyond electricity**—From hydrogen production to district heating to desalination, there are myriad opportunities for nuclear to deliver more than baseload electricity. This initiative will investigate potential regulatory and operational changes necessary to seize those opportunities and how the industry will need to change to do business with new stakeholders.

Success in these important areas relies on an innovative culture, which is why EPRI's Johnson hopes that the next GNFI in 2024 will include a hard look at what has been accomplished and what remains to be done. "Hopefully, we will build on what we have learned and continue to develop culture across the industry. I think we need to come back and look at what we have done, how we have applied what we learned in London and pushed the industry forward, and how we grow in the future?" Johnson said. "We have to review what we have done because, without self-reflection, we won't make progress."

EPRI TECHNICAL EXPERT

Sam Johnson, Wynter McGruder

Photos from the 2022 Global Forum For Nuclear Innovation held in London, UK

About EPRI

Founded in 1972, EPRI is the world's preeminent independent, non-profit energy research and development organization, with offices around the world. EPRI's trusted experts collaborate with more than 450 companies in 45 countries, driving innovation to ensure the public has clean, safe, reliable, affordable, and equitable access to electricity across the globe.

Together, we are shaping the future of energy.

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