"One of our Priorities at EPRI is to Continue Making a Difference with Respect to Innovating, Including in Nuclear Energy"

Interview with Rita Baranwal ı Vice-President, Nuclear and Chief Nuclear Officer of the Electric Power Research Initiative, EPRI

Rita Baranwal

Vice-President, Nuclear and Chief Nuclear Officer
of the Electric Power Research Initiative, EPRI

Dr. Rita Baranwal is Vice President of Nuclear and Chief Nuclear Officer. She has overall management and technical responsibility for the research and development activities conducted by EPRI with its global membership related to nuclear generation.

Baranwal joined EPRI in January of 2021 and leads a sector that provides research and development (R&D) to more than 80 percent of the world's commercial nuclear fleet.

Before joining EPRI, Baranwal served as Assistant Secretary for the Office of Nuclear Energy in the U.S. Department of Energy (DOE). She led efforts to promote R&D on existing and advanced nuclear technologies that sustain the U.S. fleet of nuclear reactors and enable the deployment of advanced nuclear energy systems.

Prior to the DOE, Baranwal directed the Gateway for Accelerated Innovation in Nuclear (GAIN) initiative at Idaho National Laboratory. Under her leadership, GAIN positively impacted over 120 companies by providing state-of-the-art R&D expertise, capabilities, and infrastructure to support deployment of innovative nuclear energy technologies.

Before GAIN, Baranwal was director of technology development and application at Westinghouse.

Baranwal is a Fellow of the American Nuclear Society.

She has a bachelor's degree from the Massachusetts Institute of Technology in materials science and engineering and a master's degree and Ph.D. in the same discipline from the University of Michigan.

What are your strategic priorities for the Nuclear Office at EPRI with respect to the national U.S. perspectives and programs as well as the international developments?

EPRI is an independent, nonprofit organization that provides industry expertise and collaborative value to help the electricity sector identify any issues and gaps in technology and serve broader needs through effective research and development programs – all in the context of benefitting society. What truly led me to join EPRI in January 2021 was its public-purpose mission and its global research and development leadership. EPRI is more than just nuclear, and that is another reason why I was drawn to this organization – to learn more about the rest of the generation sector and also learn more about grid reliability and power distribution around the world.

One of our priorities at EPRI is to continue making a difference with respect to innovating, including in nuclear energy. Our sector does it relatively well now, but I want to continue advancing nuclear R&D. This is part of the need to change how we're doing business in this industry. The nuclear sector more or less quietly chugged along for the past 40 years, and that used to be fine. But things have changed over the past five to ten years and now it's important to move quickly and more nimbly in technology transfer. We need to continue to leverage technology that was not invented in the sector when it's beneficial. When it comes to innovation, we need to be failing fast, pivoting, and moving on to the next iteration of a concept to better utilize technology. That's a bit at odds with the fairly conservative nature of the nuclear industry.

We need to continue to leverage technology that was not invented in the sector when it's beneficial.

This approach requires finding that delicate balance where we tell our researchers and staff, "Yes, every calculation you do that the fleet depends on has to be 100 % perfect." They're relying on perfection. But then we turn around and say, "OK, as you're in the lab and you're developing the next technology or the next widget, fail fast, apply those learnings, and move on." These two messages need to be carefully balanced, and I look forward to building this into our approach at EPRI.

Another priority is to ensure that nuclear's role in worldwide decarbonization efforts is realized and appreciated. It's always been a clean energy source, but we haven't typically talked about it in this way and we need to. Moving quickly also applies to the way in which we talk about nuclear's role in our global clean energy future. I've seen improvements with this over the past five years and the industry continues raising the bar. Everyone communicates it in their own way, but the point is to talk about it. I advocate for folks to talk about why they are passionate about working in nuclear and how it benefits the community and the world. When you have a nuclear power plant, why does it matter? It creates jobs. It creates tax revenue. It provides clean energy in terms of electricity, but also now we're starting to explore production of hydrogen which can be used in manufacturing plants and the transportation sector. We're starting to impact more than just the electricity sector with nuclear power. One, if not more, of those facets typically resonates with the general public. So if we talk about why

we do what we do in those terms, we may change any misperceptions of nuclear.

Finally, EPRI is placing priority on accelerating the introduction and delivery of our training initiatives. We've put a lot of work into developing common initial training programs, so rather than having individual entities amend or maintain their different training programs, we have a common program that we can share with our members who have existing fleets, are updating their fleets, or are embarking on deploying new nuclear fleets.

EPRI covers almost all technical aspects of nuclear power, starting with fuel through the whole lifetime of the plants and back-end. Are there technical levers for improving the competitiveness of conventional, i.e. large scale nuclear new build in advanced economies or is this a purely financial or market design question?

There are always technical levers that can be used, because anything leading to a power uprate or similar improvement reduces the effective cost of the technology. That being said, the greatest impacts to large light water reactor (LWR) economics will be related to market design. The top five cost drivers of nuclear construction are craft labor costs, civil or structural design, constructibility, materials, and inspection. EPRI's research directly addresses these drivers in several ways. One way to reduce labor costs during the construction phase is through schedule reduction. Manufacturing major components is costly and time-intensive, and any transformational improvements to reduce the time to completion for all aspects of the supply chain can improve overall economics. EPRI is working toward this through advanced manufacturing techniques during the fabrication of reactor pressure vessels. I took a tour of our lab at EPRI's Charlotte, North Carolina office during a recent visit, and it was exciting to see the work happening there on powder metallurgy-hot isostatic pressing and electron beam welding.

One way to reduce labor costs during the construction phase is through schedule reduction.

Our plant modernization program at EPRI explores how technology transformation is adopted in other industries. For example, we can leverage what's happened in the gas, chemical processing, and manufacturing industries, and apply what we've learned to the power sector to reduce operating costs and simultaneously improve reliability. The research results from that work are applicable to the existing nuclear fleet, as well as new nuclear reactors, which include hightemperature gas reactors, molten salt reactors, and liquid-metal-cooled reactors.

I'm optimistic that we will see substantial success in the near future. In this decade.

EPRI also has programs dedicated to phases of a nuclear plant's life. Digital twin technology is one area we're working in to enable more digitized plant design, maintenance, and operations. Much of the guidance and industry best practices can be applied in both conventional and new build environments. This knowledge transfer is especially crucial as more and more designers and developers of existing plants are retiring and there's not an adequate system in place to preserve or transfer their valuable experience and knowledge. The New Plant Assistance program engages owner-operators during the building phase and provides guidance to avoid construction delays. Startup support, safety assessments, and structural health monitoring are also part of this program.

The major economic rationale for Small Modular Reactors and small advanced reactors is serialization and standardization. This means that next to reactor design and materials development there is need for the development of manufacturing methods and processes. Does this already take place and what are the challenges for the industry as well as EPRI?

Yes, there is a need for standardizing manufacturing methods and processes. Many of these are in development or being applied, and EPRI's research is contributing.

EPRI's Advanced Nuclear Technology (ANT) program focuses on supporting the deployment of new nuclear plants. The program's mission is to reduce risk and uncertainty through innovation at each stage of the deployment lifecycle: from siting and design to construction and initial operations. Specific goals and targets are built into the program that are focused on facilitating, and ultimately standardizing, innovative technologies to maximize a plant's sustainability, economy, adaptability, and reliability.

In addition to supporting R&D for new reactor technology, ANT is helping to develop, apply, and strengthen the methodology and process by informing resource planning and supporting plant startup. Some of these activities include: supporting early-stage supply chain setup to align build requirements with key resources; creating a framework for risk-informed decision-making; developing maintenance and training guidance and procedures, and collecting, assessing, and sharing operational lessons learned in the advanced reactor (AR) environment.

One of the primary challenges is moving advanced reactors from concept to deployment. There have been several different types of technologies that have demonstrated technical promise and feasibility in the past 70 years. None have yet achieved the reliability and cost-competitiveness of light-water reactors, but the industry is making enormous progress. It seems like there is news of collaboration when it comes to testing and deployment around the world almost every day. We may not see every developer out there today who is in the process of developing a concept commercializing technology. That's just the nature of new business, right? Much fewer than 100 % will be successful. But given the funding levels that we are seeing in these types of technologies from venture capitalists, philanthropic organizations, and government, I'm optimistic that we will see substantial success in the near future. In this decade.

Of course, there are other challenges being addressed. One example is supply chain readiness, particularly in the U.S., where existing commercial reactors rely on uranium fuels with up to 5 % enrichment. Many advanced reactors require higher assay fuels with enrichment levels of 5 to 20 %. Commercial enrichers currently cannot enrich above 5 %, so developers rely on down-blending from a stockpile maintained by the U.S. Department of Energy (DOE). Proactively engaging suppliers early on in the reactor design process to keep them abreast of the designs and requirements is increasingly an industry priority. There are many new and novel advanced manufacturing techniques that didn't even exist 10 to 20 years ago, so to be able to apply those and design concepts in coordination with what can be done is really game changing in the

industry. For example, EPRI is currently engaged in a DOE-funded project to reduce costs and accelerate deployment of SMRs through improved fabrication technologies including electron beam welding, powder metallurgy-hot isostatic pressing, diode laser cladding, bulk additive manufacturing, and advanced machining. Such improvements could produce cost savings of up to 40 % and expedite the SMR manufacturing process to less than one year.

Another challenge is the testing infrastructure needed to qualify materials and equipment used in advanced reactors. The current infrastructure supports the testing needs for the existing fleet. However, with new materials and new equipment, the needs for advanced reactors are different than that of the existing fleet. Globally, the infrastructure is out there, but we need more of it.

Nuclear has always been a clean energy source and must be part of a solution to decarbonization, not only for states and countries, but the world as a whole.

The Nuclear Regulatory Commission (NRC) recognized the limitations of the licensing process; it is costly, outdated and wasn't developed to accommodate advanced reactors. That's especially a deterrent for next-generation nuclear technologies which require substantial upfront investment and early feedback from approval agencies. To address these challenges, the NRC has made massive changes to the regulatory requirements that will be expected for advanced reactor deployment. So, the NRC is changing along with the developer community.

Despite the challenges we're working through, it is a really exciting time to be in this industry. It's because of all of the technology that is starting to really be leveraged and come together to help deploy new reactor concepts, for example. It's also because nuclear has always been a clean energy source and must be part of a solution to decarbonization, not only for states and countries, but the world as a whole.

Another significant opportunity these new technologies are bringing about surrounds workforce opportunities and development. Nuclear energy also facilitates energy equity. SMRs and advanced technology make it easier to serve populations in very diverse locations. Microreactors are perfectly suitable for remote communities and for island communities. Take Alaska, for instance. Right now, they rely on expensive diesel to be transported in to help generate electricity for them. If you can envision a microreactor instead, you are reducing the reliance on that fossil fuel and also creating small communities that can have a microgrid and a microreactor and be very self-sustained. A similar solution can be applied to the electricity needs of Puerto Rico. So those types of scenarios are creating different markets where a gigawatt-scale reactor may not be the right fit, and an SMR or microreactor may be perfectly suitable. It's very interesting to see the worldwide attention and hunger that is out there for new nuclear technology. To me it's a very exciting time and a great time to be in the business.

We have developed a visioneering report on scenarios to enable large-scale, demand-driven, non-electricity markets for advanced reactors.

Next to established companies in the nuclear sector there are a number of start-up companies developing new nuclear reactor types and concepts. Is EPRI involved with them on technical challenges?

Yes, and this is exciting, as well. As an independent, industry-facing research organization, EPRI works to bridge the gap between R&D at universities, national laboratories, and technology commercialization through industry. We're at the center of some powerful partnerships and collaborations. A couple come to mind. The U.S. DOE has provided $5.1 million to fund EPRI's electron beam welding research to support NuScale Power's SMR design. EPRI is working with Kairos Power on their ARDP project; EPRI is focused on developing critical elements of their monitoring and NDE program and developing guidance for the basis for their molten salt chemistry program.

There are others. Southern Company is looking to build the world's first fast-spectrum molten salt reactor based on TerraPower's molten chloride fast reactor (MCFR) technology. The MCFR can be scaled up for commercial use on the grid and could flexibly operate on multiple fuels, including used nuclear fuel from other reactors. EPRI is among several entities Southern Company will work with on this project. We have developed a visioneering report on scenarios to enable large-scale, demand-driven, non-electricity markets for advanced reactors.

Finally, we recently introduced a Fusion Forum to demonstrate EPRI's R&D capabilities in the primary markets for a commercial fusion power plant to the growing fusion reactor developer community. We're also actively engaged with the U.S. DOE's INFUSE program (the fusion counterpart to GAIN) and ARPA-E fusion programs.

Looking into the future beyond 2030: will smaller, modular NPPs become mainstream and dominant in the new build market or will there be coexistence of large and small NPPs?

There is no one-size-fits-all approach to address decarbonization. Success will depend upon balancing nuclear energy, renewable sources such as wind and solar, and other clean energy resources. We'll need to look to a combination of traditional, larger and existing NPPs, as well as smaller ones of new design to optimize nuclear energy production.

At EPRI, we recognize this and are addressing the opportunities through research focused on supporting both the existing fleet and facilitating innovative technologies. When it comes to the existing fleet, more than 90 percent of U.S. nuclear plants have been approved by the NRC for an additional 20 years of operation beyond their original 40-year license, and they have demonstrated their capability to continue reliable operation. Our nuclear sector at EPRI developed the technical basis and guidance to inform those plant license extensions for long-term operations, and we've developed research goals for supporting the "hybrid" NPP infrastructure in 2030 and beyond. These include:

- Establishing international guidance benchmarks for end-users, utilities and non-electric users
- Establishing design paradigms that are accepted as standard in the industry
- Publishing topical reports and guidance documents on use, safety and security requirements for new nuclear fuels and spent fuels

- Demonstrating artificial intelligence (AI) modeling for manufacture of high-temperature materials
- Using non-destructive evaluation (NDE) equipment for inspection and advanced manufacturing techniques
- Developing economic modeling for AR projects
- Supporting supply chain development/refinement for AR environment
- Leveraging lessons learned in island-decoupling and modular construction

Which potential is there for non-electricity nuclear products such as process heat, district heating, desalination or low-carbon hydrogen production?

There is tremendous opportunity. Current hydrogen production is 75 Mt. A projected 520 Mt will be needed to meet demand by 2070 – a seven-fold increase. (Source: IAEA) Where will this hydrogen come from? Potentially, 117 Mt could be produced by the existing fleet. Using 30 % of nuclear output capacity could yield 35 Mt of hydrogen. Global support of non-electricity uses of nuclear is growing, particularly for applications working in tandem with other renewable sources. Although it's sensitive to market conditions and government policy, it has great potential for reducing emissions while boosting nuclear's bottom line and expanding integrated energy systems. What's especially interesting is that advanced reactors offer different opportunities than existing light water reactors because of the higher operating temperature for some designs and the ability to include specific features in the design phase.

Preserving and uprating nuclear to deliver the benefits of 24/7 carbon-free generation is among the keys to success.

EPRI's Nuclear Beyond Electricity initiative conducts research in this area. It explores how nuclear plants can be an important contributor to the net-zero carbon goals set by governments and industry and outlines opportunities for nuclear to best serve the future needs of energy consumers through energy storage, water desalinization, grid services, hydrogen production, industrial applications, operational flexibility, and isotope production. EPRI issued a Nuclear Beyond Electricity landscape report in March 2021 that will facilitate an approach to optimizing the participation of nuclear and other clean energy sources to serve society in non-traditional ways.

A major obstacle to the development of nuclear power is the regulatory fragmentation which weighs more heavily today and in the future for smaller units than in the past and on large reactors. Are there initiatives to either unify or mutually recognize the regulatory frameworks for more international opportunities and competition among manufacturers and in the supply chain?

One good example of international collaboration amongst regulatory organizations is the Memorandum of Understanding (MOU) that was signed between the U.S. Nuclear Regulatory Commission and the Canadian Nuclear Safety Commission in August 2017. That MOU was aimed at collaborating on technical reviews of advanced reactor technologies, including SMRs.

Where do you think the current U.S. administration with President Biden will head with nuclear given in their climate policy ambitions?

As we know, the Biden administration has pledged to reduce U.S. economy-wide carbon emissions to around 50 % of 2005 levels by 2030, with a goal of 100 % carbon reduction by 2035 for the electricity sector. Similarly, the International Energy Agency's (IEA) "Net Zero by 2050" roadmap supports plans for decarbonization.

This is truly exciting news for the nuclear industry and our work that is so vital to our global clean energy future. In anticipation of the Biden announcement, EPRI developed a scenario to determine the degree to which decarbonization must accelerate in the power, transportation, buildings, and industrial sectors to achieve the 2030 goal.

To achieve the goal and deliver affordable, reliable, and equitable energy, EPRI's preliminary analysis showed preserving and uprating nuclear to deliver the benefits of 24/7 carbon-free generation among the keys to success. The "clean, green" benefits of nuclear will help support its prominent role in both plans, in the U.S. and globally. Nuclear energy has a proven track record for providing 24/7 reliability, cost-effectiveness, scalability, energy services beyond electricity, jobs and socio-economic benefits. Perhaps best of all, the pledge places nuclear squarely in the center of the clean energy dialogue and brings opportunity for education and awareness-building.

The mitigation of climate change has been the major driver of the recent "rediscovery" of nuclear power globally. In the US debate nuclear was considered as an important area of geopolitical competition with China and Russia too. Will we see a renewed American leadership – as President Eisenhower´s "Atoms for peace" initiative in the 1950s – in the peaceful use of nuclear power for both reasons in the future?

I'm optimistic that the answer will be yes. As I mentioned earlier, nuclear has recently become a topic of conversation in response to decarbonization goals, and this presents a unique opportunity for the industry to shift perceptions, which in many cases are misinformed and outdated. In many ways, it's a once-in-a-lifetime opportunity to help EPRI shape attitudes and actions when it comes to energy sources and applications. It's up to the nuclear industry to make the most of it, not only by collaborating across continents and breaking down traditional barriers to make all the fantastic research and technology a reality, but also by sharing our personal passion and stories.

Author

Nicolas Wendler
Head of Media Relations and Political Affairs
KernD (Kerntechnik Deutschland e.V.)
nicolas.wendler@kernd.de