CERAMIC TECH CHAT

Episode 37

Title – "New technologies for nuclear energy: Rita Baranwal (E37)"

INTRO

De Guire: "I'm Eileen De Guire, and this is Ceramic Tech Chat.

> Nuclear power has been an important contributor to the United States energy portfolio since 1958, when Westinghouse Electric Company built the first commercial nuclear power plant in Shippingport, Pennsylvania. At nuclear energy's peak in 2012, there were 104 operating reactors, and by the end of 2021, 93 commercial reactors operated at 55 nuclear plants in 28 states.
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> Despite nuclear power's importance, few nuclear reactors have been built in recent decades. Nuclear reactors in the United States, for example, are on average 40 years old.
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> Building a new full-size reactor is expensive and time-consuming. So instead, utilities are starting to focus on smaller, modular reactors that would generate hundreds of megawatts instead of thousands."

Baranwal: "By modular we mean that some components can be fabricated in a factory and then shipped to site and installed on site. That reduces the construction time of what would be a traditional stick build of a reactor on site. And that factory fabrication also results in predictability, as one would expect when you do fabrication in a factory."

De Guire: "That's Rita Baranwal, senior vice president for energy systems at Westinghouse Electric Company. She is responsible for the development of the company's new AP300 small modular reactor. Today we talk with Rita about this new reactor and the role she believes nuclear power will play in the future energy portfolio."

(music)

SECTION 1

De Guire: "How important is nuclear power generation to the energy portfolio today, and is it different in the United States than abroad?"

Baranwal: "Nuclear power is very important to the energy portfolio of the United States. It is responsible for 50 percent of our country's carbon-free electricity. Our power plants operate 24 hours a day, seven days a week, which makes them the ideal zero-carbon complement to renewable energy sources. If we talk about how important nuclear power is in the world, there are over 430 operable reactors around the world. There are almost 60

reactors under construction worldwide. And all the operating reactors are the world's second-largest source of low-carbon power. And that's 26 percent of the total, using 2020 data."

De Guire: "What's the largest source of low-carbon power?"

Baranwal: "I believe it's hydro for worldwide."

De Guire: "Ah, okay, alright. So today there's a lot of emphasis on electric vehicles, electrification of transportation in general, which will require a robust charging infrastructure. What role does the nuclear energy industry see for itself in an electrified transportation scenario?"

Baranwal: "So all of those electrified vehicles will need a reliable source of electricity, and the nuclear power industry stands ready to provide that clean electricity that's going to be needed for what we hope is a boom in the use of EVs worldwide."

De Guire: "Okay. And as we mentioned, just a few weeks ago, Westinghouse announced a new ultracompact small modular reactor technology called the AP300. And you're leading that effort."

Baranwal: "Our AP300 is based on our larger AP1000 reactor that has been constructed and is being operated successfully in China as well as here in the United States, in the state of Georgia. It is based on proven technology, and it is based on license technology. What makes it ultra compact is its smaller footprint. It can fit on about one fourth of a soccer field."

De Guire: "So how long does it take to build an AP300?"

Baranwal: "So we are envisioning 36 months from the start of construction to the time that we can connect the unit to an electrical grid.

De Guire: "That's pretty fast."

Baranwal: "It is. And that's based on the experience that Westinghouse has constructing new nuclear reactors. And we are applying our lessons learned from our AP1000 builds in China and in the United States. And we're using those lessons learned to really target what the cost and schedule drivers were for those construction projects and apply them to the AP300 construction projects. And that results in a decreased construction schedule."

De Guire: "Okay. And about when would you expect that the AP300 would be ready to start, I guess, selling orders or taking orders?"

Baranwal: "So, we are ready to take orders now. But in terms of a deployment timeline, if you will, we just recently submitted what's called a regulatory engagement plan with the Nuclear Regulatory Commission [NRC] in the United States, and that really lays out how

we plan to get our design certified by the U.S. NRC. And in that plan, we delineate the steps that we're going to follow, but we anticipate having our designs certified by the U.S. NRC in the 2027 timeframe, after which we anticipate it will take about three years to develop a site-specific design and licensing plan, and then in 2030, we anticipate the start of construction. With that 36-month construction cycle, that puts us at 2033 for connection to the grid. So about 10 years from now."

De Guire: "Wow! And that's probably pretty fast for the nuclear industry."

Baranwal: "It is for the nuclear industry, yes."

De Guire: "So, what kinds of applications are envisioned for a small modular reactor versus like a large reactor, which basically pumps out energy for the grid. How are the applications different?"

Rita Baranwal: So, some of the applications are actually similar, but it's just a smaller output. For the AP300, we are anticipating not only the output of traditional electricity, but it can also be used to provide district heating. It can be used to provide process heat. It can be used to generate hydrogen in a clean way. It can be used to desalinate water, the process for which currently is very fossil intensive. And so, using a clean energy source to desalinate water, I feel very poetically, provides a double benefit to any community. You have cleanly produced electricity as well as cleanly desalinated water. And then finally, these reactors can also be used to generate lifesaving medical isotopes, both, for example, cancer detection as well as cancer treatment."

De Guire: "Thank you for that. I had no idea that there were so many side benefits, almost byproducts of the process that are useful. It seems like it's a very tidy kind of technology. All of it gets used, in other words."

Baranwal: "Absolutely. And we call it beyond electricity applications."

De Guire: "Right. So, there's a lot of talk about the hydrogen economy right now. Hydrogen fuel for thermal processing, like in our industry, the ceramic industry, there's a lot of interest in hydrogen firing and stuff. But, of course, the big problem, where's the hydrogen going to come from and can we get enough? So, do you think the hydrogen byproduct, there's going to be a high enough volume to help support an infrastructure like that?"

Baranwal: "So, we definitely can use the heat as well as just the electricity that's produced from nuclear power plants to generate hydrogen cleanly. At Westinghouse, we are focusing on high-temperature steam electrolysis, and we are working with partners around the world to continue to explore and then finally deploy the use of nuclear power plants for generating hydrogen cleanly. We just recently were a recipient of a U.S. Department of Energy funding award to work with Idaho National Lab and a few other partners on developing this technology further using nuclear power as that clean source to generate hydrogen."

De Guire: “So, there’s really a lot of power being driven on a couple of fronts there. It’s really an exciting idea. Nuclear power plus the hydrogen, lots of pathways there.”

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SECTION 2

De Guire: “So you are trained as a materials scientist. So, going back to that early decision, what was it about materials science that interested you?

Baranwal: “So, early on, when I was just entering college, I toured a couple of different departments because I wasn’t sure which engineering I wanted to major in. And when I toured the materials science and engineering department and saw the scanning electron microscope in the microscopy lab, it truly was an ‘ah-ha’ moment for me. I remember thinking, ‘I want to major in whatever it is that lets me use that piece of equipment.’ And so I majored in materials science and engineering.

Very fortunately, my first job after graduate school, I was able to focus on microscopy, both SEM [scanning electron microscopy] and TEM [transmission electron microscopy]. It really was a turning point for me. And so, I encourage when I talk to students, both in K–12 as well as in universities, that being exposed to different options and opportunities is very, very important. It can tell you what you want to do and also it could tell you what you may not want to pursue. But being exposed to that opportunity is very crucial in how we may be guided to pursue a particular field.”

De Guire: “And how did that lead to a career in the nuclear industry?”

Baranwal: “So my first job out of graduate school, I was actually hired to use what I had conducted my dissertation work on, which was the synthesis and characterization of nanopowders. I was hired to use that kind of work to develop new nuclear fuel for the U.S. Navy’s aircraft carriers and submarines. But then that project was eventually canceled within a year.

And shortly after that time, I was asked, if you will, I was asked or volun‘told’ to take a van full of summer interns to the Newport News Shipyard. And frankly, that trip was another turning point for me because during that trip, we had the good fortune to visit the Ronald Reagan Aircraft Carrier as it was being constructed, and I was able to stand inside where the nuclear reactor was going to be, so the reactor compartment. And I looked up several stories, and I realized that what I was working on back in my small lab in Pittsburgh was going to help power this behemoth of a ship and defend my country.

And it was almost in that moment that I really began to appreciate the immense power density that uranium provides, and the energy that it can provide to help not only power power plants for creating electricity for terrestrial application, but also to help power reactors that will help defend our country.”

De Guire: “Interesting, yeah. And so you’ve never looked back from there, it sounds like.”

Baranwal: “Absolutely, never looked back.”

De Guire: “Yeah. Recently, you served on the policy side of the industry as assistant secretary of nuclear energy at the United States Department of Energy. Can you tell us what your role was and what’s the impact that you were able to have? And how does that experience inform what you do now in the private sector?”

Baranwal: “So, the role of assistant secretary of nuclear energy in the U.S. Department of Energy is the top role in the administration on the civilian nuclear power side. And the impact was pretty phenomenal in that we were able to influence policy and how it benefits the commercial nuclear sector in the United States. In addition, helping U.S. commercial technology developers deploy their technology around the world. What was really impactful was oftentimes I was the only seat at the table that was providing that nuclear content into policies that were being developed. So, not only for terrestrial applications, but also for space reactor applications. So, it was a very interesting role, very impactful. And I’m very proud of the work that the team was able to deploy in a pretty short amount of time.”

De Guire: “How long was that appointment?”

Baranwal: “So, by the time I was nominated by the president and then confirmed by the U.S. Senate, I had after that a year and a half in the role before the administration changed.”

De Guire: “Well, that sounds like you were able to hit the ground running—and fast!”

Baranwal: “I had a very good team that supported me and was very driven to get results implemented quickly. And I think one area that I want to comment on is that most of my tenure was during COVID-19. And so, it really is not only remarkable the impact that we had on the industry, but it’s a testament to the team at DOE on the work ethic that they put forth despite all of the challenges that we saw, all of us experienced globally, during the pandemic. I like to say we really didn’t miss a beat and continued to make progress with the new programs that we wanted to launch and implement, including, for example, the advanced reactor demonstration program and making all of those funding awards on schedule, despite the fact that the teams are spread out all across the country trying to work remotely, just like the rest of the world.”

De Guire: “That’s great to hear because with energy being such a critical technology, and, you know, it really drives everything. It’s really great to hear that our government was able to continue with its policies and implementing, like you say, the research grants and things that will keep us moving forward in the direction we need to go because we need energy to manufacture, we need manufacturing to drive economies. And there’s a lot of tied-in value too in other ways, like ‘economic justice around the world’ kind of issues. So, it all matters. How do you think that impacts your return to the private sector, having seen the policy side?”

Baranwal: “It demonstrates to me how important it is for us, as a private sector player, to make our voice known to those that are in the policymaking space and to make our opinions and, for example, our wishes known to help inform policy.

When I was assistant secretary, I had many different companies come to visit me and put their requests in, either be it for funding or be it for a policy change or a new policy. And prior to that, I would absolutely tell you that I did not have an understanding of how important that interaction was.

So, having been in that role, having seen the interaction between the private sector and government, I have a much better appreciation for how we can work not only with the U.S. government side of things but how Westinghouse interacts with governments around the world.”

De Guire: “Right, because it really is a partnership.”

Baranwal: “It really is. Yes.”

De Guire: “So, you’re a Fellow of the American Nuclear Society and a member of our society, The American Ceramic Society, and maybe you belong to some other similar organizations. But from your perspective, what role do professional societies fill in the technology ecosystem?”

Baranwal: “I think the societies are a very crucial part of our industry. The professional society ecosystem helps to hone our leadership skills. There are so many different committees and subcommittees and lots of opportunities for folks to sharpen their leadership skills. When you bring that back to the workforce, that translates into if somebody wants to become a manager or move up the management chain. Or if they want to move up the technical ladder, those leadership skills do also translate back to the workplace.

So, I think it’s important to have these opportunities to learn from other leaders, but I also think it’s imperative for leaders to share their experiences with those that may be new to the industry or new to a certain segment. It’s really good to hear from somebody who has risen in the management ranks.

As a female in the nuclear industry, I remember thinking early on that it really wasn’t a big deal. And I remember somebody kind of clarifying for me that it’s almost, you know, an imperative for me to share my experience and participate in things like Women in Nuclear. That’s a professional society that we have in the nuclear industry. And it made sense after it was explained to me, because I didn’t have a role model that was like someone like me during the earlier time of my career, my leadership career.”

De Guire: “That’s interesting that you didn’t really give a whole lot of extra thought to being a woman in the field. What do you think it was that made it possible for you to advance rather smoothly?”

Baranwal: “I would chalk it up to probably tenacity and articulating what I wanted to somebody who could probably make a decision. And I learned that actually pretty early on in my first job, which happened to be at Bettis Atomic Power Laboratory.

We had an opportunity to work on a project with NASA to develop reactors to go to Jupiter to explore its icy moons. And I thought, ‘Oh, that’s what I want to work on. I want to work on that project, and I know they’re going to pick me, and I’ll just wait.’ And then I thought about it, and I said, ‘Well, let me go tell my director that I’m interested just in case he doesn’t know.’ And I went and I talked to him and I said, ‘When the opportunity comes around to have materials engineers on this NASA project, I want to be part of it.’ And he said, ‘Oh. Well, thanks for letting me know because I had no idea that you were interested, and we weren’t going to pick you or name you on that team.’

And so it was an early lesson in sharing my wishes. They may not be heeded, but at least we have done our job in terms of making our wants and desires known. Fast forward, I did get to be on that NASA project, and that wouldn’t have happened had I not sort of raised my hand and indicated my interest.”

De Guire: “Yeah, proactively.”

Baranwal: “Right.”

De Guire: “I think that’s an important thing to realize, that it’s okay to ask for it.”

Baranwal: “Right.”

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BREAK

De Guire: “ACerS’ numerous Committees offer members a way to engage with the Society and to hone their leadership skills. From coordinating publications and meetings to developing DEI initiatives and selecting award recipients, members are sure to find a Committee that aligns with their interests. Learn more about ACerS Committees at www.ceramics.org/acers-committees.”

SECTION 3

De Guire: “What other innovations are in the pipeline for nuclear power?”

Baranwal: “So, we are, for example, at Westinghouse, we do actually have a robust portfolio of different reactors, the largest being our AP1000 reactor, whose nominal output is 1,100 to 1,200 megawatts electric of power. We talked about our AP300, whose nominal output is 300 megawatts electric.

We also have our eVinci microreactor that is between 5 and 10 megawatts electric output. That reactor is designed to support remote communities, island communities, it can be used for military applications, for data server applications, we have some universities that are interested in this type of technology, as well as it can be used to support mining operations. So, our eVinci microreactor is the smallest reactor that we have in development.

And then we have our lead fast reactor, which is considered a generation IV reactor concept. So that means it's the next evolution in terms of reactor design. And that is looking to be deployed in the 2030s.

In the area of fuel development—and I think this is of interest to the ceramics community—we have our EnCore fuel line. EnCore is really fuel that's advanced, and it's in the class of accident-tolerant fuels.

And so our EnCore fuel product line is in three different phases. We have traditional fuel that is coated with chromium to provide enhanced benefits to the cladding. So that's the exterior tubing that houses the fuel pellets. Then we have kind of a mid-term advanced fuel that looks at not only that coated cladding but combines that with advanced fuel pellets. So looking at fuel pellets that are doped with, for example, chromium and aluminum, and using that with the coated cladding to provide a synergistic effect. And then we have what is more of our long-term EnCore fuel, and that's using silicon carbide cladding, so a silicon carbide tube, that houses advanced fuel pellets. And we're envisioning uranium nitride fuel pellets in that ceramic cladding."

De Guire: "Is uranium nitride used now as a fuel pellet, or is that still in development?"

Baranwal: "It's still in development. It has been explored previously, but it is not currently used widely. It does provide more benefits, but it still needs some R&D work to be used, I would say, in a commercial sense."

De Guire: "Okay, alright. So, those are a few of the ceramic and glass developments going on as it relates to the fuel and the cladding. Are there any other areas of a reactor where there are some ceramic or glass materials challenges that need to be solved?"

Baranwal: "I think there can be a greater use of ceramics in the nuclear industry if we leverage the advances that we have seen in advanced manufacturing, more specifically in HIPing [hot isostatic pressing] as well as in additive manufacturing. There is substantial work that can be done understanding starting materials, so starting powder materials, because of course the characteristics once you additively manufacture a component using that material is going to be very different than a subtractively manufactured component. So, those are some of the challenges. We're working with different national laboratories as well as universities to help us address those challenges so that we can be more successful in leveraging the newer manufacturing techniques that have come around over the past several years."

De Guire: “So, I’m just curious. As you look at things like new manufacturing technologies, are these things that could show up in something as near term as the AP300? Or are those kinds of developments farther out?”

Baranwal: “For the AP300, we are really relying on using the components and the manufacturing techniques that had been proven in our AP1000 construction. So, I don’t anticipate too many changes in the AP300 design. So to answer your question, I envision implementing these new manufacturing techniques more so in our eVinci microreactor and our lead fast reactor concepts as we move forward.”

De Guire: “Okay. Do you think there’s an opportunity in underdeveloped areas of the world for nuclear power?”

Baranwal: “Absolutely. And the IAEA, so the International Atomic Energy Agency, the term that they use is newcomer countries. And so there are many newcomer countries that are interested in nuclear power. We at Westinghouse certainly support deploying new nuclear. I feel in particular our AP300 is a very good option for any community that is interested in providing clean electricity to its community but may not want to embark on deploying a large, gigawatt-sized reactor in that community at the moment.”

De Guire: “I really like that term ‘newcomer’ much better than ‘third world.’ I’m going to remember that and try to start using that.

Rita, thank you so much. Do you have any final thoughts? Is there anything that you’d like to emphasize that we haven’t talked about yet?”

Baranwal: “I think I’d just like to emphasize that the nuclear power industry is a very exciting place at the moment. Our time is now. Not only for terrestrial applications, but also continuing to provide robust, reliable power to maritime applications as well as for space applications. So, in a nutshell, nuclear power is very exciting for sea, land, and space applications, and Westinghouse is really proud to be able to be a part of it.”

De Guire: “Excellent.”

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CONCLUSION

De Guire: “This is an exciting time for the nuclear power industry as it creates new solutions for clean energy, and ceramic innovations are ready to help the industry shine.

I’m Eileen De Guire, and this is Ceramic Tech Chat.”

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“Visit our website at ceramics.org for this episode’s show notes and to learn more about Rita Baranwal and Westinghouse. Ceramic Tech Chat is produced by Lisa McDonald and

Until next time, I’m Eileen De Guire, and thank you for joining us.”