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TECHNICAL SESSION - T9

REIMAGINING NUCLEAR'S ROLE IN ENERGY AND THE ELECTRIC GRID

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TUESDAY,

MARCH 8, 2022

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The Technical Session met via Video-Teleconference, at 3:00 p.m. EST, David A. Wright, Commissioner, NRC, presiding.

PRESENT:

DAVID A. WRIGHT, Commissioner, NRC

ARSHAD MANSOOR, President and Chief Executive Officer, Electric Power Research Institute

SHANNON BRAGG-SITTON, Director, Integrated Energy & Storage Systems Division, Idaho National Laboratory

MICHAEL MELTON, Business Development Manager, X-energy, LLC

KEVIN ROUWENHORST, Technology Manager, Ammonia Energy Association

C-O-N-T-E-N-T-S

P R O C E E D I N G S

MR. WRIGHT: Good afternoon, everyone, and welcome to Session T9 of the 2022 Virtual Regulatory Information Conference, the RIC. This session is entitled Reimagining Nuclear's Role in Energy and the Electric Grid. My name is David Wright, and I'm one of the Commissioners here at the U.S. NRC.

And before we go any further, my panel members would like to know a little bit about you, our audience. So we have a live poll in question that, Mr. Producer, I'm going to ask you to put up and open for live voting. And that'll provide that information to the panel.

So please take a moment and vote and again leave the question up so that we can see it populate, Mr. Producer. You can put it up. Is it up? So while he's getting that live polling question up, I think I want to briefly thank our two people.

I want to take a moment to thank Candace de Messieres for her passion for this topic and for the time and skill required to organize the panel this year as well as for her efforts to organize our first panel, the Electric Grid, last year. So

Candace, not only are you knowledgeable, this and many other topics, you're also a pleasure to work with. So thank you.

I'd also like to thank my staff, the staff of Team Wright, for their help and attention to detail on this panel as well as in support of the plenary session where I gave my RIC remarks just a couple hours ago. So based on the results that we're seeing, it looks like a lot of them are in nuclear regulation followed by operating reactors. And it's pretty heavy on that, and new advanced reactor seem to be falling third. So it gives you an idea of who you've got listening to you today, gang. So Mr. Producer, you can now take down that first question. I appreciate it.

Today's panel is going to focus on the reimagine role of nuclear in a carbon free future. With nuclear providing both electricity to the grid and process heat energy for applications such as hydrogen production, fuels, fertilizers, steel, plastics, chemicals, desalination, space heating and others. So the session features across sector perspectives and examples from a number of experts here we've got lined up on how the safe and secure use of existing nuclear technology to address near term and future needs for a resilient and reliable electricity grid and heat energy sources.

So that's going to lead is real quickly to our second live polling Question No. 2 which is, are we ready for the future? So Mr. Producer, if you could put that up so that we can open it for live voting. And what I'd like you to do, audience, if you would, based on what you know on this topic, do you believe we are ready for the future or not?

And so we're going to leave it up for a minute while it populates and I introduce the panelists of the group that we got. We got an awesome group of presenters today. And I believe you're going to learn a great deal from each of them as we address this topic.

So to maximize our time for this topic today, I'm going to give a brief introduction for each panelist. But I would encourage you to please visit the speaker pages of the program and agenda to view their full bios. It really is an impressive group of experts.

Kicking off today is going to be Dr. Arshad Mansoor, President and Chief Executive Officer of the Electric Power Research Institute, known as EPRI. Dr. Mansoor will start with a short video and will follow that with high level overview and vision of nuclear's role in a carbon pre-future. Next we will be -- he'll be followed by Dr. Shannon Bragg-Sitton, Director of Integrated Energy & Storage Systems Divisions at Idaho National Labs.

And she is going to provide some technical and economic perspectives on the topic as well as some near term and current initiatives and projects. She will be followed by Mr. Mike Melton, Business Development Manager at X-energy. And he will follow with a presentation on advanced nuclear's role in helping to meet future electron and non-electron energy demands and hopefully address the regulatory nexus a little bit.

And then last but not least, he's going to be followed by Dr. Kevin Rouwenhorst who is live from Netherlands today. And it's nighttime there. And he's going to provide some technical and economic perspectives and speak to the current and future role of nuclear in ammonia energy production. So a user, that's going to be -- that will be very interesting.

As the panelists present, we'll have time for some questions and answers. But please put your questions in the chat as we go along as the panelists can view them and possibly address them in their remarks. And so looking at the live polling results, most people think we're not ready. An overwhelming amount of people think we're not ready.

So thank you for that. So Mr. Producer, thank you. You can take them down now. And with that, I'm going to turn the floor over to Arshad Mansoor. Doctor, the floor is yours.

MR. MANSOOR: Right, thank you, Commissioner Wright. It's always been an honor and pleasure. And good to be back after a year, and what a difference a year makes.

I think we have never been in the time in the history the role of nuclear, reimagining the role of nuclear for clean, affordable, and reliable energy. There wasn't a time that was more important than now. And one year had made actually quite a bit of difference when we were there last year to today.

When I wake up today, you look at the forward pricing day ahead in Europe, it's 500 dollars per -- 500 Euro per megawatt hour which is around 600 dollars per megawatt hour. Then you look at what's happening in the Ukraine, the suffering of the people, the brave people who are running the nuclear power plants in safe operation. Energy is becoming critical in every aspect.

And the role of nuclear is going to be even more critical. Country after country in just 12 months have announced that they're going to go back to nuclear. France is a great example of that. State after state in United States where West Virginia and other states that had a moratorium on nuclear, they're looking to advance nuclear.

So in that backdrop, and if you go back six months ago when we had the COP26, the UN Climate Summit in Glasgow, that was also a milestone because aspirations of different countries on clean energy became ambition. And ambitions are not grounded by targets. And targets not 2050. Targets near term, even in 2030.

So I want to provide a backdrop on that context of how the world reaches those lofty goals of clean energy, not just in the electric sector but across electric transportation and industry. And I'm going to show a video from a U.S. perspective what does that stretch target means. But all the countries in the world that has signed to that UN Climate Summit have very ambitious goals to 2030. So with that, if you can quickly play the video, then I'll come back.

(Video played.)

MR. MANSOOR: I hope the video provided a context on how daunting the challenge is, but it's also an opportunity. And I want to unpack it quickly on two different areas. The one area is the near term, and near term is this decade. And the longer term is next year to 2050.

So if you look at the near term, there are a couple of things that we have to do. And we will make sure that we are continuing to do that which is if you're looking from a U.S. perspective, the largest carbon free source of energy needs to be there for us to have any chance to reduce the emission at the level that we have projected in 2030 of the target of 2030. We got to make sure that the market is valuing nuclear not just as a clean energy source but a source of capacity, source of resiliency, source of inertia.

And we have seen some very encouraging signs over the last 12 months that it is happening.

We also have to make sure that we continue to operate the plant safety. We continue to look for opportunities where plant life can be extended 40, 60, 80 and do it in the right way.

There's a lot of hard work going on in industry at EPRI, at national labs to make sure that we have that opportunity to continue this asset that we have built. But the most important thing this decade that we'll have to do is we have to double down on innovation and we have to reimagine nuclear's role. And in terms of reimagining even existing fleet and I'm talking from a U.S. perspective.

We have been talking about that we need to be more flexible because we are getting more wind and solar that are variable. And flexibility typically in nuclear has meant that we will be able to maybe go down or go up, ramp up or ramp down. Some reactors can do it better than other reactors.

But now we have a great opportunity. INL and others are leading that work where when electricity is not needed, maybe that same existing power plant can actually produce clean molecules like clean hydrogen and that hydrogen can turn into liquid ammonia. So now flexibility has a different context.

There are several pilots in the U.S. that's happening.

How do you integrate an electrolyzer in the right way with existing plant? Go beyond that. Go beyond doubling down on innovation in advanced nuclear.

We are so excited just over the last I would say 18 months. Not just significant interest, interest from nations, interest from states, public funding, private funding. There's a two and a half billion dollars for advanced reactor demo that is in the job bill in U.S.

And we fully expect before this decade is over in United States there will be at least one fully operational SMR, advanced lightwater reactor type. We also fully expect that there will be an operational advanced nuclear molten salt high temperature sodium. And that would be operational within this decade and also micro reactor.

These are the 10-15 megawatt scaled reactor will be operational. You have heard announcements from Alaska. You have heard announcements from Idaho. And that is a great opportunity because that allows us to rethink nuclear.

Because when you look at some of the high temperature reactors, it can produce steam. It can produce -- it can actually produce hydrogen more effectively than what we can do today. You produce hydrogen by breaking water. And the hotter the water is, the less energy you need to break.

So whether it's hydrogen production or steam production or production of electricity, these advanced lightwater reactors with a totally different thinking on safety, whether it's redesign, totally different thinking on refueling. You may have -- there are current designs out there that are looking at a 60-year. You refuel it after 60 years.

And the opportunity for the world, Poland just signed a deal with U.S. Other countries are looking into this to regain the leadership in developing the next generation nuclear is amazing. And just in one year, we have seen so many, one after another.

And another place this year, the innovation, this decade innovation has to happen, is we need to think broadly. It is no longer just electric utilities. Yes, electric utilities need nuclear. To get to net-zero, you need advanced nuclear.

But if you look at industry, they can only go to 30-40 percent decarbonization. For them to go even 60-80-100, the industry -- cement industry, fertilizer industry, steel industry, they are looking at hydrogen and other sources that this advanced nuclear could be the producer of. So you have even world maritime organization that is looking into net-zero by 2050 for the shipping sector and either looking at liquid ammonia which could be produced from advanced reactors. And they're also now looking into actually having nuclear reactors. We have been propelling ships with nuclear reactors for a long, long time.

So I think this decade, we have to seize the opportunity to not only operate the existing plants, make sure we are operating it safely, extending the life where life needs to be extended. But also doubling down on this rethinking of advanced nuclear, both from a utility point of view, from an industry point of view. And I want to end up with a couple of things at EPRI and I think all where we have to look into in this new world of reimagining nuclear.

We have to look at EPRI was instrumental in developing utility requirements document of the advance lightwater reactor back in the '80s and early days. Well, now you're looking at a utility requirement document for very different type of reactors. And it's not -- what is a utility?

A cement company could have a small SMR and they have their own utility. And Commissioner Wright, NRC plays a huge role. The way we license existing 1,000 megawatt reactors, that needs to be revisited to look at how do you do it. In some advanced lightwater reactor design is the Power Island and the Nuclear Island totally different than what our process is.

So I would end up with a more positive note than we are not ready. We have seen sign after sign in these 12 months. And if these signs and the actions turns into reality and we are all focusing on how do we safely bring this next generation of nuclear for industries, for electric utilities, and maybe even for transportation, I think that would be one of the best things that we're doing in this clean energy transition. So with that, I'm going to pass it on back to Commissioner Wright, and thank you so much for the opportunity.

MR. WRIGHT: Thank you. Thank you so much, Arshad. I always enjoy listening to you. And you're easy to understand and you're very knowledgeable.

And a lot of the things that you're talking about, I mean, just the poll. You obviously have a brighter, more positive outlook than what we saw. Like, 79 percent of the people saying we weren't ready. And that's coming from mainly nuclear and the operating reactor side of things.

So hopefully today is going to help people understand more about what we need to do and things that we've got to -- the hoops we've got to jump through to get there. So thank you so much. And so with that, I'm going to turn it over to Dr. Bragg-Sitton. And Shannon, you're up.

MS. BRAGG-SITTON: Thank you so much, Commissioner Wright, both for the introduction and for the opportunity to speak on this panel today on a topic that I'm very passionate about. You've all just heard from Dr. Mansoor the really ambitious goals that have been established for economy-wide net-zero solutions. And I'd like to amplify what we are working on with regard to nuclear energy's role in helping us to achieve that across all of these sectors: power, industry, and transportation. And I hope when we go back and reflect on our readiness at the end of this session, the outcome will be a little bit different in that poll. Next slide, please.

So the Department of Energy Office of Nuclear Energy program on Integrated Energy System as well as partner programs across the DOE complex has been really looking at this issue for quite some time. Instead of looking at the traditional single input, single output solution where we might have a single reactor, producing electricity to support the grid, we're looking more holistically at these solutions where we can look at ways in which we can combine multiple clean energy generation technologies such as nuclear energy, working alongside renewables to meet a wide array of energy demands. Now this could mean better coordination within a grid balancing area, or it could mean that we are directly integrating these generation technologies behind the grid interconnect within an energy park scenario.

So right now, if we have a region that

has a significant amount of renewables, when renewable generation is significant, some of those nuclear plants, the traditional base load supply maybe has to dial back that power output. But if we look more holistically at all of the energy demands, both for the electricity grid and industrial heat users that we might also couple within these energy parts, we now have a means in which we can dynamically deliver the energy produced to the grid or to these other energy users, potentially replacing some of the traditional resources utilized for thermal energy such as fossil fired units within an industry application. So when renewable generation is high or demand is potentially low, we can redirect high quality heat as well as electricity to these coupled industrial processes.

Now one of the questions we have to address when we look at these holistic solutions is what about the reliability of meeting that demand in that coupled industrial application as well? Well, that's where we begin to look at the role of energy storage which you see at the very center of this image or that could be in the form of electrical energy storage. Or it could be thermal energy storage providing longer duration storage and an opportunity for coupling those nuclear plants with an industrial application.

Or it perhaps could be chemical energy storage such as the production of hydrogen that can then go on to produce electricity during peak power demand or to support other applications as well, such as transportation and industry. But looking at this in more of a holistic framework, we can begin to understand ways in which we can maximize how we utilize these generation resources thus maximizing how we utilize that invested capital to put those systems in place. That makes sure that those generators remain profitable.

But then also they maintain affordable energy to the customer while also maintaining grid reliability and resilience. We can also look at this with the environmental lens to minimize not only emissions to the air of CO_2 and other greenhouse gases but also looking at the footprint of these plants, minimizing land utilization and water utilization. So we are looking across the board at integration opportunities for large scale lightwater reactors, high temperature advanced reactors, and also very small scale micro or small modular reactors, matching those sizes to the intended application and to the technologies that they may be coupled to on the renewable side. Next slide, please.

So when we look to these solutions, they truly are a wide array of opportunities that can be supported via nuclear energy. And I want to remind you that this would also potentially incorporate those renewables in the region. But I'll focus on the nuclear side for this particular audience.

Now when we look to integration opportunities, they might involve thermal integration or electrical integration behind the grid or even the production of process intermediates such as hydrogen. And click once more, and you'll see how all of those begin to become feedstocks to a number of industrial applications on the right side. There should be one more image that pops up on this slide. I'm not seeing it.

So I'm going to go ahead and keep going. We can actually provide connection to the chemical industry, petroleum refining -- there we go, thank you -- as well as many of these areas that are significant emitters. And we can prioritize those areas that we evaluate based on energy use, temperatures of operation, and the potential to reduce emissions overall.

In this way, we can better exploit the capabilities of our nuclear systems which is primarily a provider of heat that we traditionally convert to electricity. Now coupling to some of these processes may require that we upgrade that heat going through a number of heat augmentation opportunities such as chemical heat pumps or recuperation to ensure that those temperatures match well to the needs of the process. For example, we may need to boost the heat from a lightwater reactor to better match the demand for high temperature operations of hydrogen production.

I'll note that hydrogen is a highly versatile energy carrier. And that has been one of our high priority areas because of this versatility. If you just scan down the right side of this image, you can see that light blue arrow going into many of these processes in industry. And that is that versatile energy carrier that can be transported and it can be stored.

One area that we're looking into more

deeply is the production of synthetic fuels where we can use captured CO2 working with that hydrogen to produce these drop-in fuels that can support the harder to abate sectors such as the airline industry and provide those drop-in liquid fuels. We're also working deeper into carbon conversion processes. What this means is taking those traditional fossil-based resources that would be utilized for electricity production or for heat in industrial applications and looking at that as a feedstock, a carbon resource that can provide higher value products to consumers such as plastics, polymers, or asphalt for our roads.

And in this way, we can convert some of that income to those communities that currently rely on the fossil fuel industry from the sale of those fossil fuels for electricity production to higher value products. Changing this energy transition in those communities from a potentially negative economic impact to actually economic growth in those communities. And so if we'll go to the next slide, I want to talk a little bit about how we evaluate these different opportunities.

One of the first questions that we have

to ask is whether or not these systems would be competitive. So this first example looks at the estimated cost of high pressure steam produced using natural gas or produced using nuclear energy with this slide focusing on that produced with existing fleet lightwater reactors. You see a range of steam temperatures for lightwater reactor technologies as a function of plant size, how many units might be operating on a single site, and the capital investments necessary to upgrade the plant to provide steam as a product.

On the diagonal lines, what you see is some price points for natural gas and thus the corresponding cost of steam from those resources. And those numbers come from the Energy Information Agency. Overall, what you see is that we're already competitive.

The price of steam from a lightwater reactor can be competitive today with a natural gas package boiler. So this gives us opportunity to really look at where we can make impact in the industrial emissions area. Next slide, please. So when we began this process, we needed to develop an approach to evaluate these potential opportunities.

It was a long list of options that we could support using high quality heat, steam, and electricity from a nuclear plant. So how do we choose the best ones, and where do we choose to deploy those? We did find a need to develop a tool set to help support that because most of our tools used in industry focus on those single inputs, single output systems and don't look at these cross sectoral solutions.

So just stepping quickly through that process, we need to identify appropriate scenarios based on where we'd like to deploy such a system. We need to understand the renewables availability in that area. We need to understand what type of reactor might be of interest.

Is there an existing reactor or a potential new reactor that we might build? And what are the energy needs that would be met? Is it flexible electricity supplies we discussed earlier, or is it also a provision of heat and hydrogen and water purification to those communities?

We can then look at the data inputs necessary to drive those scenarios. This means looking at data for societal energy demand. What is it today, and what do we expect it to be over the next several decades out to that 2050 timeline perhaps?

And we can then approximate what the plant capacities might be that we bring together. What are the size of those demands that need to be met, and what size plant might we want to build? And what are the associated timelines for those? What are the lifetimes and maintenance scheduled associated with these plants that we're now talking about directly integrating and bringing together?

Then we look to the economic aspects of this. What is the capital investment required, operating costs? What is the energy price expected to do over time? Is it expected to go up? How much is it expected to evolve? All these pieces come together into this suite of analysis tools that allow us to give a very quantitative look at both the technical potential and the economic potential of these systems.

On the right, you see an example plot from this process where we're beginning to look at optimization of the size of a hydrogen production facility at an existing fleet lightwater reactor that is operating in a wind dominant region. So on the x-axis, you see the high temperature steam electrolysis capacity, the size of the hydrogen plant. On the y-axis, you see the size of the coupled hydrogen storage facility because we need to make sure that we not only provide electricity to the grid but that we always meet hydrogen market demands as well.

And then on the z-axis, what we see is the hydrogen market size and how that is expected to grow. And we can optimize the net present value by building a system at the right size. Then if you'll click once more, you can see that in the next step, we can look at how that energy would be dispatched once we build that system. See, it's not updating yet on my screen.

But in the lower plot on this next click, what you'll see is a time evolution of grid prices over a multi-day period. And that rises and falls as a function of demand and a function of what wind is being produced. At times of low grid price, what we see is hydrogen being produced and sent to storage.

When the grid price is high, corresponding to high electricity demand, we can dispatch that hydrogen from storage while we send electricity from the plant to meet grid demand. So in this manner, we can shift where the energy from the nuclear plant is going, whether that is going to electricity production for the grid or to support that hydrogen production. Let's go ahead and go to the next slide. We might see that image I just spoke of.

Yes, so you can see that evolution. But I'm going to go ahead and move on unless we run out of time. So to do these types of analyses, we did find that gap in the commercially available tools. So we developed this tool suite for a techno-economic assessment and optimization.

This falls under what we call the Framework for Optimization of ResourCes and Economics, or FORCE. And bottom line, this allows us to integrate very detailed dynamic physical models of those plants. So we really understand the time evolution of how they operate with the technical and economic optimization to assess the performance potential of these systems. And those tools are available open source and can be accessed by anyone. And we encourage feedback so that we can continue to enhance those tools. Next slide, please.

Now those tools are being utilized to assess the potential for a number of different projects. And at the national laboratories, we've partnered with a number of folks in industry to evaluate very site-specific potential for co-location of hydrogen production. So these aren't just computational analysis.

We are now moving to steel in the ground demonstration projects. The first two projects listed here focus on electric, behind the grid electrical integration of hydrogen technology, lower temperature electrolysis, with those nuclear plants. They are operating in different regions and therefore responding to different external signals on how that energy is shifted between grid support and hydrogen production.

But the first of these will be in producing hydrogen at the Nine Mile Point plant in New York in October of this year with the Davis-Besse plant in Ohio producing next year with installation of hardware corresponding with the outage planned there. In the third project, we move that next step forward. We move to high temperature thermal integration of high temperature electrolysis with that nuclear plant operated by Xcel Energy.

So we begin to lay the framework for these highly efficient operations and understand how that co-location may work and how we may move through the regulatory and licensing process associated with that. And finally, the fourth demonstration at the Palo Verde Generating Station in Arizona will move from these small scale systems to that much larger scale hydrogen production at that site where that hydrogen in that case will be utilized within gas peaking turbines to meet peak demand. And they will also pilot a syngas facility for the production of synthetic fuels. Next slide, please.

Now one of the questions we get asked is, how does this impact safety of the operation? How does it impact licensing? So my colleagues within the lightwater reactor sustainability program have conducted a generic probabilistic risk assessment to evaluate just that, identifying the top hazards and concluding that the licensing criteria is met for co-location of a large scale high temperature electrolysis facility located within a kilometer of a generic lightwater reactor.

Now this would have to be repeated for specific sites based on those specific plants and geographic locations. But this gives us promise of this potential for co-location of these systems. Next slide please. Now we don't just jump straight to deployment at a nuclear plant. We also have opportunity for electrically heated testing of these complex integrated systems within a laboratory at Idaho National Lab.

And this just quickly allows us to understand how we integrate these diverse generation sources. We have power and energy systems represented on the right side of the laboratories. We can understand how these systems would operate within a grid infrastructure, either a microgrid or a larger balancing area.

How they would interact and distribute energy to thermal storage or to hydrogen production. And we have a laboratory that sits across the street that mocks up a control room. So we understand the human operator interface with these more complex integrated systems. And next slide, please.

This is my last slide. I just want to point out that again my colleagues at the lightwater reactor sustainability program have also established a group that allows us to more deeply evaluate co-location and production of hydrogen at these existing fleet sites. And that will provide a roadmap and a framework for new advanced reactor deployments as well, with members of industry and the national laboratories coming together to discuss these issues within a number of subcommittees that evaluate internal and external events, integration of these operations of the facilities and reactor impacts, electrical and switchyard integration, potential control system approaches, and then the overarching regulatory strategy.

So if you'd like to know more and get engaged with that group, please reach out and I'll get you in touch with them. So finally, my last slide is just to say thank you. And I look forward to your questions and comments.

MR. WRIGHT: Thank you so much. So thank you, Shannon. When Candace first met you virtually, she called me as soon as you hung up with her and said that you were going to be perfect for this panel and she was right.

Your passion for your work shows. And

you really do what you do. Your work embodies what the reimagined role of nuclear in energy and the grid is going to be about. So thank you so much for your comments. And hopefully, we'll have a lot to share during Q&A for you too. So next up is Mr. Mike Melton. Mike, the floor is yours.

MR. MELTON: All right. Thank you very much. Welcome to everybody. Thank you, Commissioner Wright and the team for having me. And you're right. Shannon is a tough act to follow, but I'll do my best. So next slide please.

A little bit of information as we get into X-energy and their capabilities. But just pause how amazing it is not just in the country but worldwide how things are coming together. The environmental consciousness, the technology breakthroughs, and the political alignment, we just haven't seen these kind of forces coming together.

And these three forces need to turn around at 75 percent no we saw. So we'll work on that. I mean, we can do it. One thing about the political alignment just to comment, it's tremendous work at the Department of Energy and the technology advancements support all types of technology, let alone advanced reactor demonstration project.

But also kudos to the state legislatures, city councils out there all across the country. They're taking a good look at their energy needs, the unfortunate coal plant shutdowns, the job impacts, and the socioeconomic impacts. And they're pulling together and saying, what can we do to change things and change things for the better, the states?

So we see a tremendous amount of momentum, and we want to be part of it and help support that as a solution for the country. Next slide, please. So a little bit about x-Energy, so this is advanced reactor technology we will deploy to actually help solve the greenhouse emission issues and decarbonization goals.

But at x-Energy, we're here in Rockville, Maryland. Just a little bit, our main reactor is the Xe-100. It's an 80 megawatt electric net, 200 megawatt thermal reactor high temperature gas, Gen-IV gas reactor. So we'll talk about more in this presentation and the niche that it builds.

We're also working on a mobile reactor which in turn is called a micro reactor. And so that's currently going on with other departments in the government. But as far as commercial applications, we might be able to start talking about that in 2027 at which point these mobile reactors offer tremendous, tremendous value for remote communities and also areas hit by emergency conditions.

So we're looking forward to that future deployment in terms of human welfare, lifesaving capabilities, hospitals. We manufacture our own fuel, our TRISO-X fuel which is a tri-structural isotropic particle fuel. We've got this process under manufacture.

And I'm telling you the results and the production has been just phenomenal in terms of quality, absolutely phenomenal. And it'll be highly encouraging to talk more about that. And we also have a space application called IBX which is a different area of the company. And it's actually quite large.

But the reason we bring it up is because the culture of x-Energy in addition to creativity, taking on challenges, and simplicity. But safety is a huge focus here. And you can imagine in space, safety would be magnanimous focus, a little bit on x-

Energy. Okay. Next slide, please.

So the generation IV high temperature gas reactors has quite a bit of history, both in the U.S. and internationally, starting back with the 1960s and the UK and even as late as some of the recent designs in China that have gone online. But in the U.S., we've had experience in Peach Bottom and also at Fort St. Vrain in Colorado. It's an evolution of the technology. It's not new.

But like all things, we're making it better. And like all things, we can improve the applications. And so this technology is the nearest for deployment. And I think as Shannon was leading into the application for advanced reactor technology. So there are other industries, not just commercial electricity generation but also in mining, including the BitCoin mining, oil extraction, oil sands, process heat applications, hydrogen desalination.

As we finalize design and deployment, the application opportunities will be enormous. And the main difference -- one of the main differences besides the fuel as the coolant is helium gas versus water. So we do not need for this reactor, not the other advanced reactor designs, as much water at all to deploy these reactors. They are phenomenally simple and safe. And that's a good starting point for going forward in the future. Okay. Next slide.

So I won't stay on this too long. As I said, it's a very simple design, relies on inherently safe design features, allows us to sort of revolutionize the way the turnkey solutions are delivered, the way we put them in licensing, the reduction of effort in engineering. The goal is to improve certainty and through confidence reduce cost and have a bulletproof safety case through the licensing process.

And really when it comes to manufacturing, about a tenth of the components of a traditional nuclear plant. Once again, reliability, safety, and economics. More to follow. Next slide, please.

So the fuel is not traditional fuel I see at the commercial plans. Essentially, the fuel is manufactured here. The TRISO-X fuel has been deemed the most robust nuclear fuel on earth by Department of Energy. We'll take that.

Essentially, it retains waste and fission products within the fuel during all conditions, even the worst case accident conditions. And when you have that capability of the fuel containing your radioactive waste and gases and you can keep it the size of a cue ball, your accident source term calculations, your emergency planning zone calculations are reset.

And that safety case enables us to present potential deployment, a safe deployment, and much more locations throughout the country. So it's not new. It's a proven safety approach. And I think as we get into more details and work on a deployment, we'll see that the fuel is the safety case. And it's just a tremendous asset for the high temperature gas reactor.

Finally, from a safety case point of view, the Xe-100 meets all the Gen IV requirements for safety in terms of being walk-away safe, zero core damage frequency, all passive safety features, and resiliency. And there's a great question on the panel about resiliency we'll touch on. Okay. So next slide.

And I won't spend too much time. But these are the ladders of innovation starting with the fuel, the safe reactor, the design, leading to the standardization and integrated delivery. And we'll talk a little bit more about that because when it comes to your nuclear power plant deployments, that's where the rubber is going to hit the road in terms of can we plan, schedule, construct, and commission on schedule and on budget. So next slide.

As with most advanced reactor designs, we're working very hard with Department of Energy. We have the advanced reactor demonstration program award from the DOE with a project in Washington state. So we're talking about first deployment by really the end of the century, just being conservative, what our goals are in the 2027-2028 time frame.

The important part of this is, along with the Natrium project, we've got the recognition from the DOE as advanced reactor technology. It secures our first customer deployment. And in the industry, no one wants to be the first of a kind deployment. But the next of a kind sounds a whole lot better for a lot of good reasons.

And so we want to be able to blaze that trail, prove the safety case, prove the licensing, prove our ability with the supply chain fuel and then construction. And that actually would demonstrate your product. All that will build tremendous confidence for future deployments. Okay. Next slide, please.

All right. So what are our future deployments? Well, there's always the part about the commercial generation electricity. Really imagine a 30-acre site with a four reactor, 320 megawatt electrical station dedicated to a refining facility or ammonia production.

In the case, coal plants which unfortunately are in the closure process. But let's replace a coal plant with an Xe-100 standard plant. More so maybe we can refurbish a coal plant and install a nuclear island instead and even re-utilize some of that equipment.

And we have to do the feasibility study, the economic reviews. But there are jobs being lost to those coal plant shutdowns and there's opportunities to retrain, refill and reinvigorate these communities with the SMRs. And particularly with the Xe-100 which is advanced safety case makes it a high candidate and in direct competition with any natural gas combined cycles.

Shannon brought up hydrogen production

that is probably as big worldwide as anything. This country has moved to hydrogen production and hydrogen fuel for transportation. And we also have steel manufactures, other companies trying to replace natural gas with hydrogen as their emission source.

It's very difficult to pipe hydrogen over long distances. But we can get a plant pretty darn close or close enough for shipping. Then they'll have their dedicated hydrogen up at that point.

And of course, natural gas plants will be available because the ability of Xe-100 and the advanced reactors to ramp and perform just like a combined cycle unit just makes them tremendously attractive for greenhouse emission reduction. It's a tremendous opportunity. What's not on this slide is desalination efforts. And in Europe, the ability to provide district heat for communities has come up over and over again. And that also will be extremely important for heating. Okay. Next slide. Thank you.

And just a short slide on some of the industries that would be available for advanced reactors, just like the high temperature gas reactors for the Xe-100 which includes co-generation for electricity and steam and steam forming natural gas. So we're looking at all the potential energy markets, the industrial sectors. And what's great is they're looking at us too.

And we're working on how to match up, how to deploy. And that's the kind of audience I think the NRC would hopefully be seeing the future. We'll talk about that a little bit more. Next slide, please.

A discussion on resiliency in some of the questions really resonates where the weather plays havoc on certain parts of the country. So the move to solar and wind and for the gaps where solar can't work or wind doesn't work and battery storage doesn't work. You have to build to fill that gap. And advanced reactors like the Xe-100 can do that with very fast ramp up rates, about five percent per minute, to keep the grid stable.

So when there's a knockout going on and you need to ramp up quickly, these advanced reactors like ours, can do the job. And that is if your neighboring state has taken a hit and the whole market is going crazy, this will -- an owner of an Xe-100, a gas reactor, to actually capture some of that market and participate in the grid. So that is a huge advantage but also a huge important improvement for resiliency during emergencies. Okay. Next slide, please. It's coming, yes. There we go.

So from a regulatory nexus point of view, there will be a lot of diversity. And so the question is, are we ready? Well, we will be ready. But in terms of what's going to come to -- you can't just go put one out. You need to get it licensed with the regulatory commission. That's first and foremost. And there's coordination with FERC obviously.

So who's going to be coming to Rockville, right? So you have cogeneration and industrial process heat customers. There's factors about it, economics and deregulated markets. So that's going to be a priority for certain clients and customers. Some people are going to want it for peaking and renewable integration. We see that.

So it'll be potential partnerships with windmill companies, renewable companies that will need that stability. And then you've got the end-to-end solution providers. You've got the industry sections that just wants the steam but maybe doesn't want the plant. Or maybe they'll be a co-owner of the plant.

So these kind of deployments will generate new kinds of ownership potential that will be coming and saying, okay, what's our licensing? What's our regulatory strategy? What will we come to present to the NRC? And it'll be impressive. I mean, it will be extremely impressive to see how these developments go. So this is coming. Next slide, please.

Just a little bit of technical details on the advanced reactor landscaping, what's changing. But it's all for the better. Functional containment, mechanistic source terms, how we calculate that, how we demonstrate adequacy of barriers. This changing we're talking about different barriers now and the analysis of the computational methods, the testing, the validation work to support that.

Fuel qualification, all in process and the tremendous progress that's made already into a qualification. But as I said, the fuel is different. It's safer. It offers tremendous benefits. What is a licensing basis event or beyond design basis event for a current operating nuclear plant, completely different now when we consider advanced reactors.

So a tremendous amount of work has already been done by INL and the NRC to help define those. We'll be using that as a basis for submittals. But essentially, the conversation has changed. And what was termed as a beyond design basis event of importance for GEN-2 reactor is not important for GEN-4 reactor. And it's an amazing discussion.

Emergency planning requirements, once again, completely changed. And really it's not so much educating ourselves on these changes. But it's the public we need to educate on the changes. And the stakeholder engagement as part of the siting feasibility studies and deployment plans, stakeholder engagement is probably the biggest part of this conversation that we will talk about this. But what does it really mean to the person living in the communities, the school teachers, the lawyers, the doctors who said, is it safe?

So collectively, we need to help the communities. We need to help the state legislators. We need to help city councils turn this information into something that is useable and makes sense in plain English for the public before they allow something like this to get actually this close. They need to understand why it's safe from their question.

So we've been wrestling with that, and we're working on it. I mean, I could think of questions, but I'm too biased. Nuclear industry forever. We need people that haven't been there and what are their questions.

And that's the script we need to work on because they are a part of this approval process. They are a part of the success process. I guarantee you we can't do it without that kind of engagement in our communities. Okay. Next one. Next slide, and I'm almost done.

So talking about regulatory processes and confidence, I mean, Commissioner, it's no different than any other process. The good practices are the same, a lot of communications. When we work out who's going to be partners for a certain deployment, for a certain industry, once we work that out, we're all coming in.

And we're going to come in early. There's going to be a lot of high end communication, low end communication. No surprises on that aspect. It's so important.

Having a regulatory engagement plan and how we're going to propose regulatory approval. Essentially, there are options here with Part 50 and Part 52, Part 53 being developed. We will choose hopefully the path of least resistance or take a shot at it and go for it.

And then task and resource planning, very important. A number of policy issues always need to be identified early in the process. So I can go through this list, but essentially it comes down to a strategy which involves high level of communication, in-depth reviews on policy and regulatory requirements, path forward identified, and then an execution plan.

And it's doable. I've done it a few times. It's doable for the advanced reactors. And won't take no for an answer. So I'm looking forward to coming to the table with some new faces the industry hasn't seen before with a high level of motivation and excitement and a can do attitude because I'm telling you these are the professionals and these are the industries who know how to get work done. And we'll bring that skill set to the table.

And I think that's my last one. One more slide. Definitely a part of the team to decarbonize industry and reduce greenhouse emissions. We have a picture of the simulator here on the next slide here in Rockville. And individuals and companies are welcome to come participate and see the simulator and see how a high temperature gas reactor in all its simplicity works. And there it is. We look forward to advancing the ball. So that's all I have. Back to you, sir.

MR. MELTON: Thank you very much.

MR. WRIGHT: Thank you so much, Mike, and I can tell you're excited about the future where X-energy is headed and I know you're actively engaged at the NRC --

MR. MELTON: Sure.

MR. WRIGHT: -- and I think -- from what I hear things are going well. But to those who are out there who may have a technology, too, right, I would be remiss if I did not encourage them and tell them of the importance of early engagement with the NRC and encourage them to do just that.

Engage us early and often, just as you were doing, and thank you so much for your remarks and look forward to Q&A with you as well.

So next, Dr. Kevin Rouwenhorst of the Ammonia Association will -- he's going to be the final presenter before we get to our third live polling question and then to Q&A.

So, Doctor, the floor is yours.

MR. ROUWENHORST: Thank you so much for the kind introduction. So let me first introduce the Ammonia Energy Association. Next slide, please.

So the Ammonia Energy Association is a global industry association that advocates for the responsible use of ammonia in a zero-carbon energy economy.

So that means on the supply side we need to decarbonize ammonia production, and we see that the bigger ammonia producers - for instance, CF Industries in the United States and Yara in Europe are committed to net-zero ammonia production by 2050 along the entire supply chain.

On the demand side, we see that various industries including, for instance, the shipping industry are looking at ammonia as a way to decarbonize their energy system.

So the Ammonia Energy Association is growing in terms of members and they're globally oriented and across various sectors along the ammonia supply chain. So these are small and medium enterprises up to very large companies.

Next slide, please.

So here you can see a list of all the members of the Ammonia Energy Association. Currently, we have about 150 members, as already mentioned, across the entire value chain, and we see that the number of members is increasing rapidly. So since 2020 there has been a rapid momentum towards ammonia.

So on the ammonia production side -- next slide, please.

All right. So we see that -- yes, it's moving. So we see that currently ammonia is globally produced with a production capacity of about 183 megatons per year.

This is the second most produced chemical around the world after sulfuric acid and, essentially, all of this ammonia production is also base with about 55 percent going to urea.

In looking at the uses, about 80 percent is used for fertilizer production so mainly urea and ammonium nitrates, while some of the other uses are for the chemical industry.

Ammonia is one of the most important chemicals produced around the world because ammonia is used in fertilizers, and fertilizers sustain about half of the global population. So without the invention of the Haber-Bosch process, or the process to produce ammonia, so NH3, from hydrogen and nitrogen from the air that sustains about half of the global population.

However, there's also a downside to that. Essentially, all the ammonia is currently produced from fossil fuels. So you see that with all the colors on the right hand side. You see some colors of ammonia and some colors of hydrogen, and what you see is that about 75 percent of ammonia production is based from natural gas with the remaining 25 percent based from coal.

So, essentially, no ammonia is currently produced with zero carbon footprint. So that could be ammonia produced from green hydrogen from renewables or ammonia produced from pink hydrogen from nuclear power.

So the key message here is we need to decarbonize and our message here is that, essentially, the ammonia storage is a hydrogen -- ammonia story is a hydrogen story, as hydrogen production accounts for about 90 percent of ammonia production.

Next slide, please.

When looking at new ammonia markets developing, we see that current uses are fertilizer production so it's about 85 percent of current ammonia production and 15 percent goes to chemical production.

However, we also see that ammonia is attracting a lot of interest as a hydrogen carrier and a zero carbon fuel. So what we see is that new markets are developing so it can be -- the use of ammonia as a hydrogen carrier, to use ammonia to transport the hydrogen from locations with a lot of low-carbon electricity to locations where you need the hydrogen but not with a lot of low cost low carbon electricity to just produce hydrogen. But ammonia is also considered as a transportation fuel and as a stationary fuel.

So, in Japan, we see a lot of movement to decarbonize the current assets from gas turbines and go for power plants to use ammonia in these installations, and also for transportation fuels we see -- in the maritime market we see a lot of emphasis of ammonia as the shipping fuel of the future and we also see that when we look at the demand in the future.

So, currently, ammonia is about a 183 megaton production but by 2050 this could triple to about 600 megaton with about half of the demand going to new applications in the energy industry.

Next slide, please.

And when we are actually looking at decarbonizing ammonia production, in the one and a half degree scenario what we then see is that the current fossil-based ammonia production capacity needs to decarbonize. This means that about half of the existing fossil-based assets needs to shut down, and we also need about 500 megaton of low-carbon capacity added. So this can be done by solar and wind but it could also be done, for instance, by nuclear.

And when looking at all the announcements around the world, we actually see some momentum towards low-carbon ammonia production. So we can note that about 55 megaton of ammonia capacity just based on low-carbon alternatives, so mainly renewables but also decarbonization of fossil-based ammonia production, is announced by 2030. And you see that some -- most of this is in Australia where you have a lot of sort of wind resources but also some movements in the Middle East and also in Africa, Latin America but also, for instance, in North America.

Next slide, please.

So when looking at nuclear-based ammonia production, there are some benefits. So solar and winds are very nice. They can be low cost, but there is a drawback. They are intermittent in nature. So in that sense, nuclear could be a nice option to have a steady electricity supply to an ammonia plant.

However, when we look at literature, we don't see ammonia so much discussed in one and a half degree scenarios for ammonia production, and also when looking at literature we see a main focus on nuclear hydrogen production rather than ammonia production.

And one of the few publications on nuclear-based ammonia production is from the Idaho National Lab, and also the Ammonia Energy Association is currently working on a white paper where we assess how nuclear power could be coupled with ammonia production.

Next slide, please.

But, actually, the idea of nuclear-based ammonia production is not new. So actually already in the 1980s in the wake of the oil crisis there were the first mentions in literature of ammonia based on nuclear power, and back then the idea was to couple nuclear-based nuclear reactors with alkaline electrolysis, which had been in use since the 1920s to produce the hydrogen and then convert the hydrogen together with nitrogen to form ammonia via the Haber-Bosch process.

And what's nice about this is that in the U.S. there's currently ammonia transported by pipeline connecting multiple states in the Midwest with a total length of about 3,000 kilometers.

So you could actually transport the ammonia where you need it. However, we all know that this has not come to fruition and the main reason for that is the low cost of fossil fuels.

However, nowadays, we see increasing CO2 taxation and a decreasing cost of nuclear, of solar and wind, and the development of advanced nuclear reactors.

Next slide, please.

But there are some hurdles to overcome here because conventional nuclear reactors and ammonia plants are not always compatible. So in looking at the time to build a nuclear reactor, the efforts will take about seven and a half years but an ammonia plant takes about three years.

And also in terms of size, a renewable ammonia plant or low-carbon electrolysis-based ammonia plant would be a lot smaller than a large-scale conventional nuclear plant.

And also the cost is an issue because when you look at the ammonia market it is a very competitive market and because it needs to be as low as possible, and most nuclear reactors simply cannot provide it nowadays. And also when looking at safety, especially when you integrate an ammonia plant with a nuclear reactor, there can be some safety concerns from a regulatory perspective.

What we actually need is maybe smaller nuclear plants with a lower CapEx, for instance, via SMR so small modular reactors, or what we can do is operate current nuclear-based reactors and have long-term operation such that we can drive down the electricity costs such that we can be competitive against fossil alternatives.

Furthermore, we can also do some innovations so we can look at how we can combine, for instance, the heat output from a nuclear reactor with steam electrolysis. In this way, we can lower the electricity consumption and, therefore, get a lower cost of ammonia.

Also, we can take the best of both worlds from renewables and from nuclear, and in that way drive down the cost of the ammonia production.

But, lastly, I would recommend also not just to look at innovations but actually to implement what's already there because there are already nuclear plants operating and there are already electrolyzers operating, and what we actually see right now, which is there is going to be a nuclear ammonia facility operating in France around 2025.

So to answer the question is this possible, are we ready, yes, we are. So in France, what they have is they're going to introduce 30 megawatt grid-connected electrolysis to produce hydrogen for an ammonia plant, and in France, about 70 percent of the electricity is derived from nuclear power.

So this could be the first reference we have to produce nuclear ammonia and that way this is the first of a kind and we can roll this out through the end of the grant.

Thank you very much for your attention.

MR. WRIGHT: Thank you so much.

So that was an interesting 45 minutes or so. So, Kevin, thank you so much. I mean, as a future user of this technology, it's -- your perspective is very important here and the way you envision using it it's something that we really need to hear.

So thanks to each of you for your presentations and remarks and for your willingness to be part of this panel.

We have got a little over 15 minutes to go and before we get, you know, into the Q&A we do have a third live polling question that I'd like the audience to answer today for you, and Mr. Producer, if you'd go ahead and put it up.

And that question is what is the biggest challenge to nuclear's role in the carbon-free future? And if you'd put it up and go ahead and activate it for voting, and then I'll let you know when to take it down.

So everybody has been using the chat section. We have got some questions that are starting to come in, and I think I'm looking at the results of the poll. So all of the above, right. That seems to be carrying the day.

So thank you. You can pull down the poll now. Thank you.

To my panelists, if you want to have a dialogue with each other, ask questions, that's fine. But I think what I'm going to do is allow some of the questions that we had in the chat -- I'm going to start asking those right away.

And this one right here is -- it was initially for Arshad but I think everybody could answer it if you want. And so there's a lot of interest in going green and the Green New Deal but nuclear power seems to be left out of most mainstream discussions.

With nuclear having zero carbon emissions, there's a question as to why nuclear is often referred to as not being an environmentally friendly option when compared to wind and solar, which both require significant -- significantly more land for the same output.

The individual asking the question asked what is being done to change that discussion on nuclear such that it is considered a green power source.

So, Arshad, if you want to take the first shot or --

MR. MANSOOR: No, I'm always glass is half full. I think just look at the last 12 months and see the announcements coming from country after country. See the announcements coming from state after state.

Even in California, there's discussion from very thoughtful people on the shutdown of Diablo Canyon. So I think things have changed significantly just in the last 12 to 18 months and we have come to a point where it's no longer it's renewables or it's nuclear. It's, clearly, both, and carbon capture and storage and other clean energy solutions.

MR. WRIGHT: Shannon?

MS. BRAGG-SITTON: I'd just offer one

additional remark that I have on that. I think Arshad is correct that it's changing. It's evolving.

We're seeing the impact of energy dependence on other countries. We're seeing the language around what is considered green changing in Europe and in the U.S. across many different areas.

But I've often gotten that question in different groups and one of the ways it's been posed is how can you consider nuclear green when you don't have resolution to the fuel cycle.

And so that's always the elephant in the room for nuclear. We do have solutions. We just need to get them over the finish line and that is something that we have to resolve.

Now, that's not unique for nuclear. We have challenges to other technologies as well -- upstream materials acquisition, downstream management of the used materials -- the waste. But it is one that we always have to deal with front and center. So that is what I hear from the green energy community against nuclear.

MR. WRIGHT: Kevin or Mike?

MR. ROUWENHORST: Yes. So I would like to add on to that. Indeed, it's, in the end, not about either/or. It's and/and/and.

So you need to decarbonize fossil-based feedstock with CCS. You need to use renewable feedstocks but you also need to use the benefits of nuclear power. So we are going to need all of that, because in the end the carbon footprint will be leading here.

MR. WRIGHT: Okay. Thank you. Mike?

MR. MELTON: I agree with everything. It's just that when legislation and other documents are being drafted we'll want to make sure we pay attention to that, and I believe the conversation and the changes are happening now that renewable includes nuclear and just continue that transition. Great. I agree with everybody's comments. Thank you.

MR. WRIGHT: Okay. Let me look here.

Mike, there was a question that came in a minute ago for you -- specifically for you after your presentation and it had to do with the siting, I think, of the project and where it was going to be in Washington -- Washington State. Where? Was it at Columbia? Where was it? Could --

MR. MELTON: That's great. Yeah.

MR. WRIGHT: So the Washington State

pilot-- the format -- can you tell us where it's going to be in Washington?

MR. MELTON: In Washington State. Yes, in Washington State with the -- within this decade. It's a good public statement to make. We're a little more ambitious on that. But that's correct, in Washington State and we're working with our utility partner up there in Energy Northwest.

MR. WRIGHT: Okay. Thank you.

Shannon, there was a question that popped through earlier, and we have talked about several different ways to utilize energy created by nuclear-generating facilities.

Do you believe that the current grid system would support all these initiatives? If not, do you have any insights to scale or what kind of upgrades might be needed?

MS. BRAGG-SITTON: Sure. Let me recast that question just a little bit. So as we seek decarbonization, I see a big push in a lot of areas for electrification of anything and everything as much as we can.

The grid is not ready for that. I will definitely say that if we were to elect to electrify everything in industry, we simply can't support that and would require a significant amount of transmission, significant reduction of bottlenecking in some of these regions.

But when we start looking at integrated systems and provision of heat from these advanced nuclear facilities, that changes the equation. It changes the calculus of this such that we don't put so much stress on the grid but now we have that heat being provided to some of those applications as well.

Yes, I do think there are some upgrades that are probably needed for transmission infrastructure. We have some challenges with regard to planning tools that don't look to these cross sectoral applications where a single plant might support the grid but then shift from grid support to providing that heat -- that thermal energy -- to other applications.

So there are, certainly, some areas, but those challenges change as we look to different solution sets.

MR. WRIGHT: Okay. Let me follow up, again, staying with kind of the grid here, and this could be to all of you but I think -- are there areas that are being considered to make the grid more robust to risks that could adversely impact the grid like cyber attacks or sabotage?

MS. BRAGG-SITTON: While I have the mic I'll just say a couple of things.

DOE does have a grid modernization initiative that brings together experts across the national laboratories to look at very specific challenges and there is work with regard to cybersecurity.

In fact, we have a model called the North American Electricity Reliability -- or is Reliability or Resilience -- NAERM is the model -- that looks to these cases very specifically.

So I would say work is being done. I can't speak to detail about that. But there is, certainly, work across the board, and Arshad with EPRI may be able to offer a little bit more insight as well.

MR. MANSOOR: No, I think you mentioned the two areas. One, there is more looking to redundancy -- redundancy of substation, redundancy of lines. But what you're seeing in California during wildfires it's not a sabotage. It's a natural event.

But similar situation. When the transmission lines are down, could you create a local micro grid during the time that you shut off power upstream? That's another form of resiliency.

I think all forms of resiliency are now explored for cyber events, physical attack, but more importantly, the changing climate that is causing weather to be more extreme and more frequent.

So I think -- and nuclear plays a role in that resilient future.

MR. WRIGHT: All right. So, Kevin, a question has come in about -- and it's specifically why is hydrogen production from nuclear listed as pink rather than green?

MR. ROUWENHORST: Yeah. So I think, in the end, the coloring schemes are not leading here. I think, in the end, the carbon footprint is leading.

So, for instance, at the Ammonia Energy Association we are working on a certification scheme for low-carbon ammonia. So, in the end, it doesn't matter then what's the color. But, in the end, the carbon intensity is the most important thing here.

MR. WRIGHT: Okay. Thank you. Thank you for the answer.

Arshad, I'm going to come back at you here. So wouldn't moving towards a macro grid with diversified resources be more beneficial overall than attempting to tie specific generating technologies to specific industrial processes when the need is electricity versus steam?

MR. MANSOOR: I think it's the same answer as green. You know, green as renewables is not the only option. We have other options and macro grid is not the only option -- macro and micro grid. Both have their role to play in a resilient clean energy future.

MR. WRIGHT: Okay. Thank you for the answer.

Shannon, so have utilities assessed the need or utilization of the produced hydrogen in terms of sales, fuel for hydrogen, fuel and transport -- cars and things like that?

MS. BRAGG-SITTON: Yeah, that's a great question. What is that hydrogen market doing?

So colleagues across the National Laboratories worked a couple of years ago to look at the hydrogen market growth based on these evolutions toward clean energy systems, and based on the assumptions they saw growth on the order of four times, as much as 16 times, in the hydrogen markets that could be addressed by various resources.

And so specific markets around individual plants or utilities, those have to be assessed independently, and each of those demonstration projects that I mentioned, those are focused in different areas around our country and they have done very deep dives looking at the hydrogen markets in their specific regions, and based on the current market and the expected growth in that market, they do see a potential economic viability for doing those hydrogen demonstration projects.

And I saw another question in the chat on demonstration projects. I want to point out that those four projects I highlighted are cost-shared projects, Department of Energy working with industry to move the technology forward more rapidly.

Because we see a market there, we see that potential and we see that need and demand for hydrogen growing.

One area I love to call out is steel manufacturing. If we look at the potential emissions reduction from steel manufacturing that would utilize hydrogen in a direct reduction of iron process we can reduce the emissions from that plant by 90 percent -- 9-0 percent.

There's a huge potential market for that and we see new DRI plants being built that could be impacted by some of those demonstration projects.

Let me also point out significant investment in hydrogen being made by the U.S. Department of Energy.

If we look into the bipartisan infrastructure law, we see $9.5 billion associated with clean hydrogen production -- $1.5 billion on clean hydrogen manufacturing, storage, and transport and another $8 billion associated with establishing hydrogen hubs, one of which is specifically called out to be linked with nuclear energy technology.

So there is significant potential for market growth across transportation and industry, and this is a force that will continue to grow and we'll see this impact dramatically, I think.

MR. WRIGHT: Thank you. Thank you so much.

Mike, we'll come to you and then I'm going to go back to the panel again with a larger question.

So you mentioned that X-energy is preparing to bring in nontraditional customers that desire nuclear options. Are there any strategies that X-energy is applying that are also applicable to the current operating fleet?

MR. MELTON: I don't see why not. As we engage with the current operating fleet for other business reasons we'll be discussing those kind of strategies. But we can't get a lot done without the current operating fleet, actually, in some sort of cooperative mode.

So, yeah, there will be some strategies for, you know, addressing common resources, strengths. Definitely their experience, definitely their plant knowledge just brings so much to the table and it's like a huge confidence factor for us to have those kind of relationships, especially when we're talking about a nontraditional industry.

So yeah, a little bit -- a little bit, you know, turn the blinds a little bit -- put a little light on that. But yes, it's a resource that's supremely important to us and vital to us in the industry.

MR. WRIGHT: So from your perspective, as you see things, what are the most important regulatory considerations relating to nontraditional uses of nuclear energy?

MR. MELTON: Well, the starting point is, you know, first, assuming we get through the, you know, technology approvals, but really it's the siting when it comes down to it and it's the hazard analysis that goes along with a particular site.

So the -- not so much from an emergency planning zone. But in terms of hazard analysis, in terms of -- you know, if we're going to bunk near other industries that offer different hazards, you know, that type of analysis from a PRA -- probabilistic risk analysis -- as well as safety considerations will probably be the new part of the work that we'll mix in.

So we're looking forward to putting that together -- the safety case. But as you bring it closer, you know, they're not going to be out in the middle of nowhere. They're going to be closer to industrial centers and city centers and those hazards will be accounted for.

I think, Commissioner, that's probably

the new part that we'll be talking about.

MR. WRIGHT: Okay. Thank you.

And, Kevin, I want to come back to you real quick. Based on your experiences, how can the nuclear industry better communicate and collaborate with nontraditional nuclear energy customers?

MR. ROUWENHORST: Actually, the role of the Ammonia Energy Association, for instance, is also to bring different actors across the value chain together, of course.

So, for instance, we have the Ammonia Energies Conference where also nuclear people are there from the nuclear energy perspective, and we are working on a white paper.

But we think also an important thing here is to show the feasibility, to show with demonstrations -- for instance, in (unintelligible) in France to show that it's actually running. Actually, nuclear people should probably not talk too much how safe it is but demonstrate it works, because these are more important than talks, in the end.

MR. WRIGHT: Thank you so much.

And we're almost out of time here so I want to take a second and thank each of you very much for your participation and what you brought to the table today.

It's about telling your story. Arshad, you started off with a really great vision and painted the picture, and each of you followed and just added more color to it, and it is important that you tell your stories and, again, communicate, communicate, communicate. You know, we have got to do that.

I look forward to meeting up with you -- each of you again -- Arshad, Kevin, Shannon, Mike. Thank you again.

And with that, we will bring us to a close.

(Whereupon, the above-entitled matter went off the record.)