UNITED STATES

NUCLEAR REGULATORY COMMISSION

+ + + + +

BRIEFING ON NUCLEAR REGULATORY RESEARCH PROGRAM

+ + + + +

THURSDAY,

MARCH 30, 2023

+ + + + +

The Commission met in the Commissioners' Hearing Room, One White Flint North, Rockville, Maryland, at 9:00 a.m. EDT, Christopher T. Hanson, Chair, presiding.

COMMISSION MEMBERS:

CHRISTOPHER T. HANSON, Chair

JEFF BARAN, Commissioner

DAVID A. WRIGHT, Commissioner

ANNIE CAPUTO, Commissioner

BRADLEY R. CROWELL, Commissioner

ALSO PRESENT:

BROOKE P. CLARK, Secretary of the Commission

MARIAN ZOBLER, General Counsel

EXTERNAL PANEL:

VÉRONIQUE ROUYER, Head, Division of Nuclear Safety Technology and Regulation, Nuclear Energy Agency

DR. K. MICHAEL GOFF, Principal Deputy Assistant Secretary for Nuclear Energy, Office of Nuclear Energy, Department of Energy (DOE)

DR. JENNIFER SHAFER, Program Director, Advanced Research Projects Agency-Energy, DOE

DR. ZAHRA MOHAGHEGH, Associate Professor, University of Illinois

DR. DAVID PICKETT, Senior Program Manager, Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute

STEVE CHENGELIS, Director, Future Fleet, Electric Power Research Institute

NRC STAFF:

CATHERINE HANEY, Deputy Executive Director for Materials, Waste, Research, State, Tribal, Compliance, Administration, and Human Capital Programs

RAY FURSTENAU, Director, RES

FRED SOCK, Structural Engineer, Division of Engineering, RES

MICHAEL FRANOVICH, Director, Division of Risk Assessment, NRR

LOUISE LUND, Director, Division of Engineering, RES

THOMAS BOYCE, Branch Chief, Materials and Structural Branch, Division of Fuel Management, NMSS

`

P-R-O-C-E-E-D-I-N-G-S

9:00 a.m.

CHAIR HANSON: All right. Good morning, everyone. I convene the Nuclear Regulatory Commission's public meeting for the purpose of discussing NRC's Regulatory Research Program activities.

It's important to keep the public informed of the agency's research activities in support of regulatory needs and nuclear safety, so I thank all of you for contributing to this meeting today, both here in the room -- and I know we have several participants online as well, and I'm looking forward to a great conversation.

We'll hear from two panels this morning. First, an external panel and then we'll hear from the staff in the second half. We'll take a short break in between. And with each panel we'll hold questions to the end.

So before we start I'll ask my colleagues if they have any comments they'd like to make. No? Okay. With that we'll begin with the first panel online. We're joined by Ms. Veronique Rouyer, Head of the Division of Nuclear Safety Technology and Regulation at the Nuclear Energy Agency in Paris. Ms. Rouyer, the floor is yours.

MS. ROUYER: Good morning, Mr. Chair and Commissioners. It's a real pleasure and honor to be here today to share my views on role of safety research in building core capabilities in six minutes.

Slide 2, please? Maintaining and deploying nuclear energy must be based on confidence, confidence in the knowledge of the risk, integrating a holistic view on both social and technical elements. At the same time, research excellence policy is essential to build and maintain expertise as a tool for trust.

We don't know everything, but we have confidence in the risk analysis that is made available to decisionmakers. Their decisions should be informed by uncertainty analysis, sensitivity analysis, as efficient as possible. Then the research contributes concretely to building confidence in conservatism in the safety margins proposed by licensees and in the performance of the tools used to support the decision. This is all the more important when the decision is based on best estimate assessment and on data directly from the monitoring of the nuclear installations.

The core capabilities for efficient safety policy are our known knowledge in the behavior and in potential degradation of materials, knowledge in the design and behavior of systems, knowledge in the various safety NRC's methodologies, knowledge in methodologies for measuring and analyzing operational data. At the same time the policy of research excellence must be based on a rigorous and systemic well-known approach based on key steps.

First, applied academic research will increase knowledge on materials, systems, methods, computational techniques. Second, development of models, simulation tools or methodologies with a focus on reducing uncertainties. Third, an efficient verification and validation process of these tools based on typical case experiments. These two components of safety policy must be closely linked to be effective. This connection is established through the databases and simulation tools made available to all actors; that is to say, research organizations, universities, industry, regulators, and their technical support organizations.

Only a dialogue between them can ensure that they are in control of these elements and that they know what is behind, what the limitations are, can ensure that the problems are well-formulated with -- which is not easy and that possibilities to optimize the system can emerge. This governing dialogue is also the only way to optimize the use of full-scale experiments which are definitively essential for solving important problems or predicting significant developments because although this step is usually very costly, it is essential to the overall picture. The U.S. NRC is deploying such an integrated approach. And in particular, the NEA is happy to support any new needs it could express in terms of priority research projects.

Slide 3, please? Let me now illustrate how research should be a catalyst for addressing the safety challenges in the new dynamics of nuclear energy deployment.

It is well known that capacity consists in three key components: First, capabilities and resources; second, performance; and third, change adaptation. Research activities are essential in this regard given the critical aspects of these challenges, namely timing is critical. The availability of infrastructures is critical in terms of facilities, resources, performance, and adaptation to a new context. It is also critical to maintain the space for testing and designing innovation. It is critical to preserve space to initiate system simplifications. And then it is essential also to continuously identify opportunities for the younger generation, but also those that the younger generation can offer.

In addition, external interactions are important levers to strengthen this capacity through exchange with all research partners, through international activities, as well as in-depth peer-to-peer collaborations to identify priorities for action.

I would like to take this opportunity to underline that the U.S. NRC is a key partner in almost all the NEA safety-related activities, more than 20 joint projects and more than 20 safety working groups. In particular the inputs of NRC experts are highly valued in identifying research priorities.

I would like to thank in advance as well the NRC for its support in the future discussion that will be held within the NEA. The direction of the recommendations that were proposed during a recent workshop, namely establish a safety research board, organize a review of potential future R&D framework model, develop phenomena identification ranking tables, a database for innovative designs, and evaluate how to better engage with policy making bodies. By following the link at the bottom of the slide you will find the workshop outputs, opportunities, and recommendations in relation to a wide range of topics covered by NEA projects.

Slide 4, please? Then I would focus the last portion of my presentation on one example of NEA activities ongoing. NEA Nuclear Education, Skills and Technology (NEST) Framework. This framework has been launched in '19 to put new scientists and researchers in the real life using fellows' exchanges with NEST mentors.

NEST objectives are the following ones: With a focus on multidisciplinary skills and competencies, access to state-of-the art facilities, opportunity to develop a network, and participation in challenging and innovative activities. NEST is gathering more than 50 participating organizations from 10 countries. NEST fellows could be from master degree to young professionals for a short or longer duration depending on their background. The topics of the NEST projects are very various from hydrogen containment experiments to medical applications. You have the current list of ongoing projects on the slide and also on the web page of the project on the NEA link.

Next slide, please? So this concludes my presentation, Mr. Chair, and thank you for your attention.

CHAIR HANSON: Thank you very much, Ms. Rouyer. Next we'll hear from Dr. Michael Goff. He's the Principal Deputy Assistant Secretary for Nuclear Energy in the Office of Nuclear Energy at the U.S. Department of Energy. Dr. Goff?

DR. GOFF: Thank you very much, Mr. Chair and Commissioners. (Off microphone.)

My apologies. Thank you again for letting me -- having me here today. Let me open up with my wanting to stress how important I think our collaboration and cooperation really is, because I think it is critical. So I welcome this opportunity to talk about that here. And I think it's really critical as far as a seam setter just because of how important and how critical we think the role of nuclear energy is for both us and our allies in meeting both our environmental goals, but also our national and energy security needs, which has really just been highlighted very much so by Russia's unprovoked and unjustified invasion of Ukraine. So I think it's really important what we're doing and making sure that we're working together so we can make sure that nuclear is a vital role in meeting those goals.

One thing I wanted to highlight as part of that, we did last week, the Department of Energy, put out Pathways to Technology Deployment reports. We put out three of those last week, one on batteries, one on hydrogen, and one on nuclear. And those reports really do highlight the importance, especially of nuclear in that we are projecting that we think we need on the order 200 new gigawatts of nuclear capacity by 2050. So we need to be rapidly deploying here, starting this decade in order to meet those goals. So we think it's critical. So it's great that we're working together on this and I think we do have a good story on how we're working together.

And as Secretary of Energy continues to say, she thinks our high priority now is deploy, deploy, deploy. So we are very much focused on that and that means we've got to be working hand in hand as we're moving forward.

So, yes, going to this first slide, I think it's worth at least noting what our four main priorities that we are focused on in the Office of Nuclear Energy. The first is we want to make sure we keep the existing 92 reactors operating and moving forward safely and efficiently, because again if any of those close, that 200 gigawatts of new deployment is just going to increase. So we got to make sure that we keep them moving forward.

We also obviously got to make sure we're deploying new technology here, and that's a major focus. And then also in doing so we got to make sure that we have a sustainable fuel cycle moving forward, and that's both the front end and the back end; management of the waste, but also making sure that we have supplies of low-enriched uranium and high-assay low-enriched uranium as well for some of those advanced reactor technologies.

And the final one is we realize we're doing this not just for ourselves, but for us and our allies and partners. So we got to have increased international collaboration. And I think we are working together well across all of those different areas there.

So maybe going onto the next slide there? So we have collaborated well throughout the years, but that was highlighted a lot with the passage of the Nuclear Energy Innovation Capabilities Act, with the passage of NEICA. NEICA did actually formally codify that we need to establish an MOU on how we're collaborating to move forward on advanced reactors. That was passed in 2018 and in 2019 we put together an MOU to start those collaborations first with a major focus on deployment of advanced reactors, the passage of -- we were tasked at that point to move forward with the Advanced Reactor Demonstration Program, which was kind of a three-tiered program on looking at first the first phase of that, the deployment phase, making sure that we can deploy advanced reactors. The goal Congress gave us at that point was by 2027, having advanced reactors producing electricity on the grid, but then also having work on risk reduction reactors in the next tier. So those will be like being able to deploy five years later. And then concept development say in another five years.

So we started good collaborations on those advanced reactor technologies and you all were very supportive as we were going through the review process for those awards as well in the 2020 time frame.

We then though modified -- made an addendum. I was impressed at how -- when I went back and looked at this, how many times we have addended that MOU there. So we modified that addendum to that to focus more on as we were formally going forward with the Advanced Reactor Demonstration Program, because we realized we really have to be working lockstep to make sure that as these advanced technologies are coming forward, as those vendors are working with you to go through the licensing process that we're working and trying to support them to make sure -- having good communication and delivering the right kind of products on that. So we modified that. And I think we've had a very good teamwork. I think the teams right now meet pretty much every other week. I think there's one group that's focused on light water reactor systems. So the small modular reactors like NuScale and Holtec focus on those. And then another group that's meeting that's focused more on the Gen 4 type systems, which our two demonstration ones are a high-temperature gas reactor and a sodium-cooled metal fuel fast reactor. So they're meeting very regularly.

Within the Department of Energy as we transition also the management of those demonstration projects from the Office of Nuclear Energy to the Office of Clean Energy Demonstration, or OCED, those interactions have continued and they -- in fact, I've talked to my OCED colleagues and they are very pleased with how those interactions are going as well.

But then again we also -- NEICA also did task us, the Department, the move forward on establishing the National Reactor Innovation Center as well, for us to be able to work with industry, whether they're part of the ARDP awards or not, but to be able to work with the industry to be able to do demonstrations on moving forward. So we also addended our MOU there to have more collaboration as part of NRIC. And in fact as part of that we've also had NRC staff members imbedded within NRIC.

So as other vendors again that are maybe just totally on private funding are coming to us looking at options for demonstrating technologies, we're working with your staff also to be able to look at how we can best go forward. We may do some demonstration and testing under DOE authorization, but how do we get to the NRC authorization as well? So we've had really good collaboration as part of that as well.

And then we also continued that in testing where we're looking at like say using the MELCOR code to be able to apply that to more different technologies besides light water reactor technologies. And we've also done a lot of work as well at looking at advanced fuels as far as how we collaborate.

So maybe going to the next slide on that? We have had good long-term collaboration on accident-tolerant fuels. And again that's coming from -- a lot of our focus is what we're trying to develop we want to be able to deploy. So we want to make sure that as we're working through our public/private partnership on accident-tolerant fuels with different vendors that they are developing something that we can get licensed and qualified so the commercial utilities can be using it in the near term. And we do have in-pile runs going right now, so I think we've worked well on that.

And also worked well on just the demonstration of advanced fuels. One of the programs -- we just heard a presentation from the NEA. One of the activities that we are working well between the NRC, DOE, and Idaho National Lab is looking at how we do different irradiation testings to support either materials qualifications or fuel qualifications, especially now that we have -- there's more limited irradiation testing capabilities. We want to make sure we're using our international partners well on that, so we are doing a coordination of that as well and have signed some recent agreements to move forward on that as well.

So going onto the next slide as well, again we want to continue to expand our collaborations and continue to make forward -- move forward on being able to license advanced technologies. So we are looking at -- this year we do have a certain amount of funding through our NRIC line item appropriation that we're looking up at setting up an Advanced Reactor Regulatory Program to where we can work with industry and the NRC to start facilitating through public/private partnerships some awards toward industry as -- looking at how we interface, especially on those advanced reactor technologies and go forward and make sure that we're getting the right type information for licensing them, especially as we're looking at some of the gas-cooled reactors, the molten salt reactors, and the fact reactors as well.

So we're looking at putting in -- probably having some kind of funding announcement later this year again to industry to be able to support them in their interactions with the NRC moving forward. But also as part of that program looking at doing some additional R&D as well to help make sure we have the regulatory basis for some of those advanced technologies as well.

Finally, I just want to at least mention there were four priority areas. The fuel cycle and the international are very important to us as well. We do appreciate all the collaboration, the long-term collaboration that we've had in the waste area. We're looking forward to a lot more collaboration as we're looking at trying to make sure we have an assured fuel supply. We hope to be looking at trying to spur moving forward on developing domestic capabilities for high-assay low-enriched uranium. We will be having to work with you a lot on that as we, especially on the NEPA front, as we look at how we spur that -- those actions forward. So look forward to that -- interactions.

And I want to also stress we appreciate very much the interactions internationally. I know we participate in a lot of meetings. We are developing these technologies, not just for domestic use, but we want to be able to have them for our allies and partners. And we appreciate very much the work that you're doing and the agreements that you have as far as helping capacity build. Especially as we're looking at newcomer nations it's very critical that we make sure that we can stand up good regulatory -- or that they can stand up good regulatory systems. We appreciate very much the interaction that you all have had and the partnerships that we've had in doing that. So thank you very much.

CHAIR HANSON: Thank you, Dr. Goff, very much for your presentation. Next we'll hear from Dr. Jennifer Shafer. She's the Program Director for -- in the Advanced Research Projects Agency-Energy at the Department of Energy. Dr. Shafer?

DR. SHAFER: Yes, thank you very much for this and really thank you very much for the opportunity to come and present at the Commissioners' meeting. We're thrilled with the interactions that we've had with the NRC so far.

So please next slide? And one of the things about this is I'm not actually seeing the slides be presented on my end, so I might just go ahead and present them so I can see what's being presented to you all. Sorry about that.

There we go. Opening any moment now. Okay. Thank you very much. So ARPA-E has an extensive portfolio within the fission research space. So basically many -- there are many different ways that an ARPA-E program gets funded, and so one of them is through focused programs of which we have four. So this the MEITNER, GEMINA, ONWARDS, and CURIE portfolios. We are also starting to look at transmutation, and so this is something where we're basically evaluating the potential cost benefits, technical risks associated with transmuting, these are the actinides or fission products, and what this could mean for the overall waste management strategy.

So I'll go ahead and dig into a little bit more with respect to what each of these projects are, but for those of you that are less familiar, ARPA-E is basically an agency that has broad authority in trying to identify whether it's decreasing emissions, increasing efficiency management of our nuclear waste, et cetera, to try and deploy in these areas. And so we basically try and identify white spaces or technical areas not being addressed by our partners across the government. And so that's what we've done with each of these programs here.

So next slide with respect to MEITNER. So MEITNER was basically a program that was set up. We recognized that costs were actually critical in addressing to deploy the advanced reactor fleet. And so this was a program set up just to do explicitly that. So the goal was to develop and demonstrate technologies that greatly improve advanced reactor performance.

And every ARPA-E program has an acronym and this one was Modeling Enhanced Innovations Trailblazing Nuclear Energy Reinvigoration. And so really MEITNER was focusing on addressing technical challenges that would enable low overnight construction costs; largely autonomous operations to staffing levels; safety when considering time before intervention to an accident, potential for potential exposure to radiation; very short on-site construction time; proliferation resistance via safeguards by design; and the ability to achieve either or both easy electrical grid integration with intermittent sources such as wind or solar, and the availability to provide economical industrial process heat.

So we always have metrics in any given program, and so here we were -- had a series of metrics that we were trying to improve with MEITNER and where the state-of-the-art was at the time. And basically we were trying to move this forward rapidly. And we've had a couple of different success stories out of the MEITNER Program, one of them being the eVinci Microreactor Program that continue to sactually deploy and do very well. We are funding some of the heat pipe technology associated with that reactor.

So next slide? GEMINA. So the GEMINA Program, basically the goal here was to develop tools and cost basis for advanced reactors to achieve a fixed operation and maintenance cost of $2 a megawatt-hour without shifting costs to other parts of the LCOE.

So with this program, what we were thinking about -- we know that capital costs are expensive for reactors, but we also know that the operational costs. And the technology innovation that was being leveraged here was something that's being leveraged throughout basically other aspects of industry, whether it's power transportation, et cetera, which is how do we actually leverage digital technologies to decrease operation and maintenance costs?

And this is an area where I'll emphasize that we've had many fantastic and great interactions with the NRC as we move towards talking about what are digital twin technologies, how they differ from just digital technologies, and what the ramifications are when a system is learning on the fly and retraining itself, and how do we actually regulate that, and really emerging towards the idea that we need more demonstration of these types of tools so that we can understand what they are.

And that's actually -- as we march forward in the future with this program, we have the opportunity to offer plus-ups to program teams and sort of the next tranche of this is really going to be focusing on -- these aren't going to be large-scale demonstrations, but small-scale, sub-scale demonstrations of these types of digital technologies such that we can actually start learning more about them. And this is something that we had recognized, but it was really emphasized in meetings with the NRC how important this would be to regulators. And so that's a concrete example of how these interactions can be very beneficial.

So next slide, please? Another area where ARPA-E has been looking at things is the ONWARDS Program. And so I'm actually presenting these programs chronologically. As you might have noticed MEITNER came out in 2018. ONWARDS came out in 2021. And this program was focused on developing technologies to significantly minimize the disposal impact of waste coming from advanced reactors while maintaining disposal costs in the range of a buck per megawatt-hour, basically within the bounds of the original nuclear waste management fee.

And the global item that was recognized here when it came to ONWARDS was that for many of the potential waste emerging from advanced reactors, we don't actually have a clear pathway to disposal for them. So this could be molten-salt technologies. This could be metal fuels. These are things that we still need to think a little bit more about what their disposal pathways would look like.

And so one thing that we were very attentive to was a 10x reduction in waste volumes or repository footprint with no weakening of safeguards standards. And so we were also very attentive to improving or maintaining the one percent accuracy in fissile mass measurement in UNF processing in high-radiation backgrounds. So trying to improve that.

We also wanted to improve the proliferation resistance of uranium and transuranium materials recycling. So actually for several of the fuel forms that come out of ONWARDS there might actually be not even recycling that's required, but actually a waste conditioning step. And if you do that waste conditioning, we want to make sure that we are co-recovering the materials together. And if you are doing the recycling, we still want to make sure that we're co-recovering the materials together. So this was something that we thought would provide significant non-proliferation benefit to the materials.

And then also we wanted to look at high-performance waste forms for advanced reactor high-level waste across multiple disposal environments. And so this is basically the ONWARDS Program. And it got out the door about a year ago and we're continuing our engagement with NRC and talking about waste forms in conversations there.

And then with respect to the CURIE portfolio -- so this is the most recent portfolio that we've brought on board here, so many performers just getting started out. Here we were looking at recycling of material from our light water reactor fleet to put it into our current reactor fleet -- or sorry, our advanced reactor fleet.

And what we're thinking about here are we know that reprocessing technologies are expensive and we know that frequently when people think about materials accountancy and safeguarding technologies, this is generally thought to come with an additional cost. And the more that you do that, the more cost that there is. What we're actually trying to do with CURIE is, one, decrease the cost of reprocessing technologies in general, but also decrease the cost of the safeguarding technology and design it in such a way that it's actually a cost benefit to the facility. So now you don't have these two things in competition, but they're actually in synergy and people are actually cost incentivized to do a really effective safeguarding and materials accountancy capability with their facilities.

So we wanted to decrease waste, we wanted to maintain cost of waste disposal, we wanted to generate fuel that would be competitive with basically HALEU, with what that cost metric was driving to there. The other item that we were thinking about was we wanted to actually be able to provide predictive materials accountancy capabilities so when it was in the facility you would actually be monitoring in real time and projecting what the material would be -- output would be on the back end. So you could be finding this much sooner than standard accountancy capabilities. And then of course we're maintaining the thread of not producing a pure plutonium stream.

And I'll just take a moment to acknowledge here that I do apologize for not being able to be there in person. A big reason why that is is -- actually the only reason why that is is because we're actually flying out to

Argonne this afternoon to go visit the CURIE performers and by me staying back just a little bit, it's going to enable me to get down there and accomplish one of the meetings today. So this was something that's happening in real time.

The last slide I will speak is actually looking at what we're projecting out into the future. And so we've had great interactions with the NRC with respect to looking at digital twin technologies. We've had great interactions thinking about reprocessing and what's coming down the pike. I was able to present at the RIC with respect to what we've been doing there and open up conversations.

Something else that we've been thinking about is using nuclear heat for industrial decarbonization. And so basically the idea being that we know that nuclear heat can be used for a lot of different things, but I don't know that we're seeing it really widely deployed or widely considered for industrial applications. We are seeing that X Energy Dow interaction happen, but we are thinking that it could happen much more rapidly. And the basis for this being that nuclear actually has a really low levelized cost of heat. That's what that graph is showing on the right-hand side there.

So we're driving for program development in that space right now. We'll be wanting to engage with the NRC over the course of this. And we have a request for information. That closes today at 3/30 at 5:00 p.m.

So that is basically our last slide here. If it works ... will it matter? is the last slide, but I thank you for allowing me the time to present and I'll be happy to take questions from the Commission.

CHAIR HANSON: Thank you, Dr. Shafer, for your presentation. Next, we'll hear from Dr. Zahra Mohaghegh. She is an Associate Professor in the Department of Nuclear Plasma and Radiological Engineering and the Director of the Social Technical Risk Analysis Research Laboratory at the University of Illinois in Urban-Champaign and she is a University Nuclear Leadership Program Grant recipient. So, Dr. Mohaghegh?

DR. MOHAGHEGH: Good morning. Thank you for the opportunity. Glad to be here. I would like to share some thoughts on the UNLP Research and Development Grant today.

Next slide, please? UNLP supports cutting-edge university research, which attracts and cultivates talented and purpose-driven student who are needed to address emergent safety concerns in existing plants and to expedite the development and deployment of next generation reactors. Fostering university-led nuclear innovation and investing in the future workforce help improve the efficiency of regulation while maintaining the successful safety record of the nuclear industry.

Next slide, please? Since UNLP success requires joint effort by the NRC and academia, I would like to pose two questions: (A) What university practices could maximize UNLP impacts? and (B) What could NRC do to maximize UNLP impacts? In the next few slides I will try to present responses to these questions and support them with them examples from our experience at Illinois.

Next slide, please? To address question A, our first suggested university practice is to integrate regulatory methods and needs into educational programs. An example is the Illinois nuclear engineering risk & reliability track that offers undergraduate and graduate-level PRA courses with embedded information on regulatory methods and needs. This approach increases the chances that scholarly research can have a real-world impact in light of the regulatory landscape.

Next slide, please? The second practice is to establish strong connections between regulatory challenges and the outcomes of university scientific research. For example, the risk & reliability track at Illinois has focused on technology-inclusive risk-informed performance-based methodologies which have been used in various applications and have been acknowledged or supported by several organizations, such as the U.S. National Academies, the DOE, the National Science Foundation, the NRC, the Nuclear Power Industry, and the IAEA. The success of this project was based on the team's academic qualification as well as significant efforts to connect the risk methodologies with regulatory needs. In addition, our team has leveraged academia's scholarly objectivity while conducting research and producing results to ensure the acceptability of the work by all stakeholders. For example, our methodologies have supported closing the Generic Safety Issue 191 and Operating Plan, where scholarly objectivity was crucial for solidifying the credibility of the results by the NRC, industry, and the public.

Next slide, please? The third practice is to create strategic plans to develop complementary research topics and to progressively advance toward visionary goals. For example, to facilitate risk-informed performance-based design and licensing advanced nuclear reactors, our team has developed a strategic plan for executing activities such as the IAEA Project, two concurrent NRC UNLP grants, and several pending proposals shown on this graph. This approach allows research to progress meaningfully toward addressing real-world challenges and concerns.

Next slide, please? To address question B on what the NRC could do to maximize UNLP impacts, our first recommendation is that the NRC encourage university best practices; for example, those three discussed earlier. This could be done through dissemination and grant review guidelines. Our second recommendation is that the NRC create an additional UNLP funding category to enable NRC-endorsed groundbreaking research initiatives and enters at universities to target high-risk/high-reward research.

Next slide, please? For example, a potential response to a call within this category could be an NRC-endorsed research initiative for technology-inclusive risk-informed performance-based analysis and regulation of next generation nuclear power plants. This initiative would design a transformational regulatory-accepted platform to automate PRA model development, model updates and upgrades by integrating risk-informed performance-based analysis with modeling and simulation of underlying phenomena, digital twins, and artificial intelligence.

There have been successful examples of NRC-endorsed initiatives at universities such as those in the areas of thermal hydraulics and neutronics and we believe that now is the right time to expand this endorsement model to establish and support initiatives and centers in cross-cutting areas such as PRA to enable expedited and cost-effective implementation of a risk-informed performance-based regulatory framework. Such NRC-endorsed initiatives or centers would also attract students who are interested in cutting-edge research to nuclear engineering.

Next slide, please? I very much appreciate having had this opportunity to share some thoughts on the importance of UNLP grants and how to maximize their impact. Thank you very much.

CHAIR HANSON: Thank you very much for your presentation. And next we'll hear from Dr. David Pickett. He's a Senior Program Manager at the Center for Nuclear Waste Regulatory Analyses at the Southwest Research Institute in San Antonio, Texas, I believe.

DR. PICKETT: Yes, thank you and good morning. I'm here representing the CNWRA, which is NRC's only federally-funded research and development center. My presentation today is titled Research Supporting Long-term Storage of Nuclear Materials, but I've chosen to focus on spent nuclear fuel as that's the material with the most challenging technical issues in long-term storage.

Next slide, please? Or slide 2. Yes. I'm using long-term to mean storage of spent fuel beyond the initial 20-year period for which most storage systems and facilities are licensed, but time periods of concern vary depending on such factors as burnup and fuel history. The two central challenges for long-term storage are spent fuels will be in dry storage for potentially much longer than originally envisioned and less is known about how spent fuels and relates wastes for advanced reactors will behave over long times.

Long-term storage must be safe and compatible with subsequent spent fuel management. Thermal conditions in management timelines may differ from best past practices. There's been a great deal of productive research including by NRC, but there remain information needs that research can help address.

Next slide, please? CNWRA has conducted long-term storage research over many years. Early on we helped NRC identify regulatory and technical gaps. We performed thermal and gas flow modeling of storage systems using computational fluid dynamics. We evaluated cask-drying requirements and developed a test plan for vacuum drying effectiveness. We conducted long-term tests of stainless steels to investigate the potential for chloride-induced stress corrosion cracking of containers. We assessed instrumentation for functional monitoring of dry storage systems. CNWRA worked with the NRC research staff to evaluate degradation mechanisms for spent fuel and storage system components important to safety, including development of aging management tables that provided the technical bases for regulatory guidance.

Next slide, please? In addition to research, CNWRA has assisted NRC licensing activities. We've supported numerous reviews for storage system certificate of compliance and independent spent fuel storage installation licenses, including renewal applications. Applying the previously mentioned research on component aging, we worked with NRC to develop the

Managing Aging Processes in Storage Report which the staff applies in renewal reviews.

CNWRA provided technical support to the continued storage rulemaking. We also assisted safety or environmental reviews of license applications for centralized interim storage facilities in Utah, Texas, and New Mexico.

More recently, CNWRA has evaluated information needs and potential regulatory gaps for the storage of spent fuel and waste from advanced reactors using TRISO, metal, and molten salt fuels. The TRISO and metal fuels work is documented in numerous reports in ADAMS. The molten salt activity is ongoing with the NRC Research staff.

Next slide, please? As I mentioned earlier, there continues to be a great deal of research from outside NRC, some of which is briefly highlighted on this slide. The valuable forum for cross-organizational cooperation is the Extended Storage Collaboration Program, or ESCP, which is led by the Electric Power Research Institute, and has involved DOE, NRC, and others.

The High-Burnup Dry Storage Cask Research Project is an ongoing study in which high-burnup fuel rods are being stored for 10 years or more. The casks are monitored and the fuels eventually will be analyzed for indications of degradation. On chloride-induced stress corrosion cracking, corrosion testing and modeling continue along with consequence analyses and studies of methods for stress mitigation and crack repair. Studies of fuel condition and potential degradation continue with particular focus on hydride reorientation and cladding.

Next slide, please? What in our view are the research needs of highest priority for long-term storage? Studies of high-burnup fuel behavior should continue with observations and conclusions extrapolated to longer time periods. Research on stress corrosion cracking, the most credible mechanism for stainless steel container degradation, on relevant time scales should continue.

Attention should continue on benchmarking of thermal and decay models. Understanding the structural performance of storage systems under external loads such as seismicity is important as storage times lengthen. The wide variety of fuel types proposed for advanced reactors, some with potentially higher initial enrichments and burnups, will present an ongoing challenge to regulating long-term storage. Better predictions of criticality and thermal performance will be needed and better definition and understanding of associated non-fuel wastes will be an evolving need.

I've not mentioned other wastes to this point, but I'll note that the ongoing 10 CFR Part 61 rulemaking is driving evaluations of the disposal performance of greater-than-Class C wastes. If the need arises for extended management of these wastes prior to disposal research may assist in understanding their long-term behavior in surface storage. Thank you for your attention.

CHAIR HANSON: Thank you very much, Dr. Pickett, for your presentation. We'll finish up the presentations on this external panel with Mr. Steve Chengelis. He's the Director of Transformative Nuclear

Technologies at the Electric Power Research Institute. Mr. Chengelis?

MR. CHENGELIS: Okay. Well, thank you and I appreciate the opportunity to be here this morning. Also, I do apologize for being virtual, so, at a meeting down in South Carolina. Would have really like to have been there in person, but hopefully next time I will be.

Just want to focus in on three key areas of research that we're working on at EPRI to ensure the safe and economic deployment of the advanced reactors. So the first one is around the risk assessment roadmap. So there is a broad consensus out there right now that in order to meet our carbon-free goals, we will need to decarbonize the energy sector, more than just electricity, looking at everything from industrial, transportation, et cetera, to make sure that we can meet the 2050 goals. And as part of this, there are many models that, as Dr. Goff was alluding to earlier as well, that show a very large build-out of new nuclear.

So EPRI and the Nuclear Energy Institute, NEI, got together and said in order to -- there's a lot of work that needs to be done. In order to see the successful deployment, we need to team up together, put together a roadmap that will spur the needed actions and achieve the outcomes that will enable the successful deployment at the levels needed and demanded by society. So we've worked on a roadmap all of 2022. The roadmap is now out for -- it's a draft form, it's out for review. The roadmap outlines a path forward for ensuring advanced reactor technologies can meet the market demands. The first phase is around the North American roadmap, so we're focusing just on North America. Phase 2 will look international as well as there's a lot of build-out internationally.

This is an industry roadmap as EPRI and NEI have engaged multiple stakeholders across North America in developing it. We made sure that we got all the stakeholders together throughout 2022 and that the roadmap reflects the aggregate vision strategy and needed actions of all these stakeholders.

What going forward is we have taken the roadmap. We have put it into prioritizations. So there's 44 actions right now that will be prioritized going forward. And as we all know the key to any roadmap is the work you do behind it. So all of these actions that have been prioritized by our stakeholders will be worked on throughout this year and the upcoming years. And it will also start to influence the EPRI research portfolio in our advanced reactor space to make sure we're working on the things that are most important for industry and the successful deployment of advanced reactors.

The second area I wanted to highlight is around advanced reactor materials and manufacturing. So advanced reactors as we all know operate at much higher temperatures. They have different mechanical loads, different environmental conditions. And as part of that we need to start to develop a roadmap around the coordination of these materials development in the validation of the materials.

So this is really kind of looking at it from two different perspectives. One is advanced manufacturing. So this is changing the way that we manufacture these different components. It will influence the supply chain in one way because for instance a lot of these advanced manufacturing techniques are able to produce the components at a much reduced lead time than what you would see from a typical forging process. And also the way the materials are formed in some of these new methods is very homogenized material, no welds. For instance, you're using a powder metallurgy, hot isostatic pressing, and advanced welding techniques as well that will lead to reduced times. So reduced times, reduced inspections. And really it leads to some of the issues we see I think as well around the supply chain. This could be an alternate supply chain source.

So we are focusing on advanced manufacturing techniques. We're identifying, developing, and qualifying these techniques as well. And then on the other side of it is looking at all of the materials that are going to be used in these new operating conditions. And many of these materials right now are -- have a limited approval through the ASME Section 3, Division 5 for high-temperature materials. So we're working on that as well to make sure that we start to do the research needed to look at the different environments, different operating conditions, and that we have the -- so there -- because there's not a lot of operating experience out there so that we do the research that's going to take to qualify these materials for use in the new reactors.

The last area I want to focus on -- and that's my next slide, if you would, please -- is as we start to look at all the work that needs done; and there's a lot of new entities that are getting into the business as well, we have a whole initiative around nuclear beyond electricity. And that's looking at how can we use nuclear beyond just electrons to the grid. We're teaming up with universities, with chemical companies. And it's different than your traditional utility who's going to be the owner/operator.

So as part of that we start to put together a project development execution phase where it's combining a lot of things that you might have heard from EPRI in the past. So like our utility requirements document that has been around since the early 1990s with over 40,000 different requirements and our siting guide, which actually help lead into the first early siting permit.

But it's combining these together, taking the perspective member or owner/operator through the -- all these different stages of as I'm looking to build, I want to start off with what's my technology assessment guide? So what's my mission that I'm looking to build for? What's my business requirements? How many megawatts do I need? Do I need high temperature? Do I just need to be using it for auxiliary steam? What are all the needs? Walk them through that. And then you implement through the Siting Guide. We implement through the Owner Requirements Guide. And it's really a path that we can take to help make sure that as somebody's looking for how do I implement nuclear technology into my IRP, what are the steps I need to take? So we're working very closely on that and going through that entire portfolio of different products that EPRI has available.

As part of that we've also teamed up with Tennessee Valley Authority, TVA, and helping them -- what we're calling this mega project. As they start to think about their new builds and they move forward we're going to be working with them on this project development life cycle. And it will be kind of a living document. They'll be using it. We'll be updating it with their real-time experience and so the rest of the industry can benefit from it as well.

And then the last thing I just want to focus on is we started these new technology user groups. It's something that's actually -- the meetings are taking place this week in Charlotte where we brought together all the key stakeholders again around five key areas: light water SMR, molten salt, fast reactor, high-temperate gas reactors, and micro reactors. And the idea here is if -- looking at the current operating fleet, which we know that needs to continue to extend out as long as it can, too, because it really forms the framework around the future deployments. But those are -- majority are all light water/heavy water technology. And going forward with the different technologies that we're seeing looking to be deployed, they're going to have different needs, different needs around materials, different operating conditions, different chemistry, different maintenance. And to focus our attention on the right things we're opening up these technology user groups to make sure that our research is focused in on the specific needs of the five different areas. And we can proceed forward in a -- kind of a collaborative fashion that the research we're doing will meet those needs and it's not just based on the past technologies moving forward. So with that, I thank you for the time and welcome any questions.

CHAIR HANSON: Thank you very much, Mr. Chengelis, for your presentation. We'll now start with questions from the Commission, and this time I get to go first.

I'd like to kind of have a -- see if we can have a conversation, Dr. Goff and Dr. Mohaghegh, between the two of you and about kind of how do we use university research and other -- and grant programs like at NRC and at -- and in the Office of Nuclear Energy to develop the right skill sets that we need kind of going forward in the workforce.

In conversations with a couple of different universities one of the things that's emerged in my conversations with them was for a long time there was a lot of money for universities in materials, a lot of -- the last couple of decades it's really -- there's been a lot of focus on materials. And now we're developing new reactors and people are saying oh, wait, we really need like -- we need reactor designers, we need reactor systems analysts and other -- and so it's this kind of shift with this focus really in the last, I don't know what, two, three, four years that's kind of happened.

So, Dr. Goff, maybe you can talk about kind of is DOE engaging universities maybe in this shift or in other ways to potentially change the emphasis of research programs? And I guess, Dr. Mohaghegh, after he answers, I'd be very interested in your perspective from kind of on the ground at the University of Illinois about how you see that going.

DR. GOFF: Yes, we have evolved our program significantly and a major change this year, and hope it will lead to getting more of those right type people. The way our -- we have had the Nuclear Energy University Program for a number of years. It was more though spread across all of our programs, so we would commit up to a certain amount of our R&D funds with a goal of being somewhere in the order of 20 percent toward university-funded programs. But it was all supported directly to the programs.

So you put out a call that's in the fuel cycle area, the advanced reactor area, and it was all distributed like that. And it was -- I think, was a successful program. It provided long-term continuity for funding of the universities and all is well. But we have made a major change in that right now to -- this year, in fact. So we now have a line item for nuclear energy that's a dollar value for universities. And it is more open. So it is more -- the universities can come forward and propose what type things they want. It doesn't have to be directly tied to the programs. So it's going to be interesting for us this year to see how that does actually work. In fact, I've gotten some feedback, and obviously we have some view from the University of Illinois with our Assistant Secretary having been a colleagues of yours for a number of years there. We are hopeful that that will be more beneficial to making sure we get the people in the universities and get more collaboration with them. But it will be interesting.

In fact, I've got to admit I've heard some -- I won't say complaints from the universities, but it's like now we got to change how we go about writing these proposals. In the past, you've pretty well defined what you want. Now we've got to put forward stuff and we don't know how they're going to be graded ow. So this will be an interesting learning year for us with the universities to get this right, to make sure that we are putting something that gets the right students and the right interactions between the programs. So this is an interesting change for us this year. So I'll be real interested to hear the university perspective on the way -- on this shift right now.

CHAIR HANSON: I mean in the kind of -- in the spirit of scientific inquiry, do you have a hypothesis about how the universities are going to adapt or what you're actually going to see, or you're just kind of open to the possibilities here?

DR. GOFF: Well, yes, we're open to the possibilities. And I think there -- on that other issue is like they knew how they were going to be graded. Now it's a little bit the relevancy grade is going to be a little bit different on how they go forward with that, so how they hit that mark. I think they're going to hit the mark well. But we want to make sure that again it's fostering innovation.

One of our concerns in the past is you're not completely encouraging innovation. You're -- we want this. So now our good blue-sky ideas really come out of the universities. So we hope this will give us that more openness to be able to get some of those good innovative ideas that the universities are great at generating.

DR. MOHAGHEGH: Yes, thank you, Mike. Yes, I agree that I believe DOE's change to style of proposal -- especially this year I saw a category “Other,” which I appreciated. Means kind of a open call. And we could propose in a more innovative way without being in a box, in a specific topic. So I do appreciate that style of the DOE this year.

And in a general answer to your question, I can say in order to build the workforce, we need to generate impactful research for them, otherwise we cannot have Ph.D. thesis out of the simple -- the questions and simple problems. So impactful research generate motivation for students. So if they see the value of their research in a real-world problem, definitely they will be more excited to contribute to that research.

I have seen that students in two categories. Some student are toward sustaining research. The problem is clear. They don't want too much confusion about the problems. They want very clear. So that's why some of the style of the DOE proposal that have a clear category works for that category of student, but the other types are -- they like disruptive research. They like somebody -- some unknown unknown. And I believe in the area of the advanced reactor there are many, many opportunities. And that refers to that topic that I mentioned in my presentation. I think these type of groundbreaking research initiative and ideas, that's generate flexibility for the student to innovate in that area.

And I think DOE is very good opportunity. NRC's direct connection with these topics also valuable for motivating a student to join the workforce in NRC. I personally had a student recently join NRC through this UNLP Grant. I think Dr. Kevin Coyne significantly helped to make sure that this a win/win for both student and for -- so appreciate that.

CHAIR HANSON: Thank you. And thank you for your presentation. I thought the feedback for the agency was very helpful and focused. And you mentioned this one potential for a funding stream of kind of high-risk/high-reward. And I'm reasonably familiar with the ARPA-E Program, which is that's kind of their model, but how -- could you say more about how that might actually work for us in the regulatory space?

DR. MOHAGHEGH: Yes, I agree that ARPA-E has an option. And I believe all of these are complementary. Definitely ARPA-E is a good choice for some topics.

For the case of NRC, I'm thinking that NRC right now for advanced reactor -- in order to improve efficiency there is a real need for research to support the efficiency of the NRC for the deployment of advanced reactor. And in doing so, I believe if there is a direct line of funding through the NRC for these type of innovative project. It can be -- the research can be endorsed by NRC so that it can be in a real-time applied and used by NRC. So ARPA-E could not have that benefit of being endorsed, the results of the research, in a real time so that in a speedy way NRC can, for example, issue the regulatory guides out of the research. So therefore the research can be used by NRC in the real time.

CHAIR HANSON: Great. Thank you. Yes, really appreciate that. Dr. Pickett, I'd like to finish up with you. You had -- I was hoping you could expand on a point that you made in your presentation about the evaluation of information needs and regulatory gaps for storage of advanced reactor waste. I'm really interested and kind of concerned about our regulatory readiness for other parts of the fuel cycle, particularly advanced fuel cycle. So how are you all or how do you think we should be kind of addressing these and how significant are these gaps and so forth? Could you expand on that a bit?

DR. PICKETT: Well, yes, I mentioned that we had completed a series of reports that focused on metal fuels and TRISO fuels, and those are published. And where the information needs mostly seem to land was that these are different -- there will be different materials that -- and that the regulatory guidance for storage and transportation of these used fuels is often very specific in terms of reactors and materials. And so that -- I mean for instance, corrosion of non-fuel hardwares is something you have to be concerned about in storage.

CHAIR HANSON: I see.

DR. PICKETT: Those materials could be very different from what are in light water reactor --

CHAIR HANSON: Okay.

DR. PICKETT: -- fuel storage containers, the material properties of coatings and claddings and so forth. So that's where we end up finding the need for possible changes in the guidance was in the specificity of the current guidance to light water reactors.

Now with molten salt fuels, they're really just getting that underway, but I think that it's clear that there are materials issues there for example that will be very different from what may be in the guidance now. Different burnups, different enrichments may challenge the guidance with respect to criticality and radionuclide contents and so forth.

CHAIR HANSON: Okay.

DR. PICKETT: That's where a lot of our findings are focusing.

CHAIR HANSON: Thank you. Thank you. I noticed -- I didn't want to miss an opportunity for Dr. Shafer to jump in here. And she may have some thoughts about any of the topics here, but I didn't -- I got the high sign that maybe you wanted to jump in. Dr. Shafer?

DR. SHAFER: Sure. Yeah, no, thank you so much for the opportunity to comment. And that actually dovetails very well, because I can speak to both the original item that I was going to comment on, and then the item that I can move to, and kind of thinking about waste.

And, with respect to thinking about, you know, the question that was posed, how does the NRC perhaps dovetail with high risk, high reward research? It seemed like this was maybe a good opportunity for me to comment on that.

You know, one thing that we've really seen within, for example, the GEMINA Program, is as we're using machinery models and, you know, AI-informed models to develop various technologies, right, the technology has become less deterministic. And, I think the NRC is really, and people are thinking seriously about using and deploying these technologies. And, we know that they're deployed in other areas. We actually see them deployed in transportation currently. Many rental cars that I drive now will actually, if I don't turn my blinker on, they will adjust you in real time, without necessarily me asking that I do that, if I don't turn my blinker on and I start to shift lanes.

So, we're seeing them deployed. We're seeing them used in aviation. And, so, the question is, you know, how does the NRC ceding familiarity, transparency, trust in algorithms that are less deterministic? And, I don't think that this is going to be something, you know, that's going to be very easy to unpack in the near term. I think it's actually going to take a long time to do it.

You know, DARPA actually has an AI trustworthiness program. And, these are things that while this research isn't necessarily looking to say, oh my gosh, how risky, how. But, it's something that the NRC could be doing to better inform and familiarize itself with these topics. You know, and this actually dovetails well with the comment with respect to waste and waste management.

Another area that I didn't have time to comment on in the Agency is actually with respect to fusion materials. And, I know that this is, we aren't necessarily talking about fusion in this meeting. But, one of the things that we're trying to do here, is how do we design materials that can be deployed in fusion-based technologies? And, one of the ways that we're trying to expedite that process, is trying to get a much better sense of materials breakdown using surrogate type material, or surrogate type radiation approaches such as ion implementation instead of neutron damage, right. Because you can implement much higher doses to materials then if you're just using neutrons.

The tradeoff is that you don't actually get some of the penetration of the irradiation damage into the material. And therefore, you can miss things like spalling effects. And so, the million-dollar question that on some level ARPA-E's starting to ask, and we just had a fusion workshop on this, and we have a fusion RFI on this, is, are there sort of physical parameters that we can actually use to define the differences between surrogate approaches?

And, if we can, then this will potentially be very transformative in how quickly we're able to actually do characterization and assessment of the new materials. And you know, this is something that kind of consistently comes up in the deployment of advanced reactors, is how can we deploy better materials faster? And, so, this might also be an area where potentially some funds could be expended to think about, how do we start to understand more about the physical phenomena that underlie these things? But, those are just a couple of observations that I had.

CHAIR HANSON: Thank you, Dr. Shafer. Your comments on fusion, I think, are quite timely. And, with that, I thank my colleagues for the extra time. And, I'll hand it over to Commissioner Baran.

COMMISSIONER BARAN: Thanks. Well, thank you all for your presentations. Dr. Shafer, I'm interested in hearing more about ARPA-E's CURIE Program, aimed at enabling commercially viable reprocessing of spent nuclear fuel. What are the time frames associated with the Program? And, what have the awardees been finding? Can you give us a sense of the innovation that you're seeing in this area?

DR. SHAFER: Right. So, the program really just started. So, basically people were getting under contract as of just even about a month ago. So, it's really very early to say what are people exactly finding. And then the other piece of this is, you know, what is ARPA-E that's really funding out of it? So, ARPA-E is funding individual technologies that might be used to enable deployment of a particular technology, a particular reprocessing technology.

So, as a consequence of that, it's not like we've funded technologies and we can say, okay, as a consequence of this now, we know how the entire recycling facility is necessarily going to set up. And, you know, that kind of enabling term there. That really focuses and lies on each individual technology and potentially each individual performer. And so, as a consequence of that, you know, obviously OKLO has been interacting with the NRC, or starting to issue things there. And so, you know, they have a very different timeline that was seen than many other people within the portfolio.

And so, but for ARPA-E's role in this, we were funding specific technologies to the tune of about one to, I think the most federal funding that allocated for a given project was on the order of $6 million. And that it is just for a three-year period to get that particular technology derisked. And then, we basically move on from there. So, there's not a line item for, you know, out there, beyond the three-year period that ARPA-E will have reprocessing technology funding. The hope is that these teams get this going and then they become their own entities and able to move forward.

COMMISSIONER BARAN: Okay. Thanks. With one or more reactors interested in operating for up to 80 years, NRC and licensees are increasingly focused on aging management.

Ms. Rouyer, can you talk about how the FIDES-II Program helps address the need for research and testing in the area of aging management?

DR. SHAFER: I'm sorry, I'm not familiar with the FIDES-II Program.

COMMISSIONER BARAN: Oh, okay. That was, that's

NEA. But, I don't know, you had it on one of your slides, Dr. Goff, if you want to -- do you, can you chime in on that at all? Well, or I could save it for the next panel otherwise.

DR. GOFF: I know portions of that program were given. And, I might say, if the NEA person wants to answer too, that's fine as well. I mean, a portion of that program does look at yeah, how you can do different material studies to know the long term operate -- yeah, how those materials will behave in a long term.

And, trying to do that again in a coordinated matter between our international partners and the labs here in the U.S., again, looking at, you know, materials -- yeah, taking -- yeah, we had data for certain periods of time. We need probably additional radiation testing to support those longer periods. So, trying to do those in a coordinated matter so that not just us can benefit, but our other partners and all as well.

COMMISSIONER BARAN: Great.

DR. GOFF: I know they have a number of different irradiations that they're looking at. And trying to yeah, look at when is the right place to do that since we have a limited now radiation capabilities. So, doing it in a nice, coordinated manner.

COMMISSIONER BARAN: Ms. Rouyer, did you want to chime in?

MS. ROUYER: If I may, yes. It's just, if the, if you can just consider the fact that yes, in the framework of FIDES-II, the possibility of the objective is to address these topics of material radiation. And, in general, I would say. And, of course the problem with of choosing could be focused on aging issues. And, the real interest of this framework is to gather it in the same framework, or at the initiation level all the problems that can address any part of the problem. And then, we can have a complementary activity. It is the real interest of these kinds of joint projects, is to have at the international level a project that can be built with different phases, and in different facilities. And then, to build it with the same objective. And so, this is something that we all are working on. After the first phase of the first project that has become and discussed in the FIDES right now.

COMMISSIONER BARAN: All right. Thanks so much. A major goal of NRC's research program is to be ready for new technologies that we may need to oversee in the near future. Through that lens, I'm interested in hearing any perspectives anyone has on whether there are areas where NRC should focus whether there are areas, and what those areas are, where NRC should focus more of its research attention.

Any areas right now, as you're thinking kind of, looking at the horizon, areas where we should be doing more than we're doing in the research area?

DR. MOHAGHEGH: So, maybe my opinion is biased, because I'm kind of a risk professor, a risk analysis professor. But, I want to share this perspective, because of currently of research questions, good research questions for us is how we can justify the use of risk informed performance based, versus traditional approaches like maximum hypothetical accident approach.

Because there are debates on, it is hard sometimes for, they think some of the developers, they think that there are costs associated, there are times associated. They may not see immediately the benefit of the, the saving that could have in terms of safety and in term of cost in the risk informed performance-based approaches.

In my view, if we generate research in order to develop methodologies and tools to facilitate the use of this methodology, I think it will be helpful. And, firsthand I see that how challenging it is to communicate the aspects with developers.

COMMISSIONER BARAN: Thanks. And, Dr. Shafer, did you want to weigh in?

DR. SHAFER: Sure. Happy to. And, basically I completely actually agree with what was just said, with respect to risk and how the NRC needs to understand different risk matrices and using alternative approaches to assess risk.

I was just going to take a moment to reiterate, when it comes to new technologies, understanding how to trust and verify AI-based machine learning models that are less deterministic, I think is going to be critical for how the NRC potentially is able to look at these technologies moving forward.

And the other one, I think, that could be really critical is also understanding how you could, perhaps develop better physical models that would enable you to understand radiation damage and also predict radiation damage, such that you can maybe get by in the near term without having to do such long term irradiations to actually verify in that material. I think this kind of touches on your comment about the FIDES Program and how does it compare/contrast to what we're thinking about at the Agency.

So, basically, traditionally you do irradiations for very long time periods to understand materials breakdown. And, I don't believe that those, that need will go away in the near term. But, to the degree that you could potentially develop relevant experiments that would enable you better prediction of materials capability under short term irradiation, that would be hugely enabling.

COMMISSIONER BARAN: Okay, great. Anyone else have anything else they want to? Yeah?

DR. PICKETT: I can be very brief. Disposal, I think, you know, when it comes to advanced reactors, I would suggest the Agency get further ahead on the ultimate disposal.

COMMISSIONER BARAN: Okay. Great. And, you were the only one who had previously, in your slides, gotten to this question. And, you had a whole list of things that you think we should focus on. So, I appreciate that. Thanks everyone. And, I'll turn back the rest of my time.

CHAIR HANSON: Thanks, Commissioner Baran. Commissioner Wright?

COMMISSIONER WRIGHT: Thank you, Chair. And good morning to everyone. Thank you for your presentations.

Again, partnerships are what it's about and learning and this, you know, and partnerships with the likes represented on this panel. Right? You've got government research labs, nonprofits, universities, international organizations. That's -- it's only through those, you know, efforts, working with you that we're going to be able to set appropriate research guidelines, and strategies, and priorities, and also work toward providing the resources that are necessary. Right? To support, you know, what we consider our mission critical work and also the things that you have to do in your world. So, and it also is very important to the American people.

So, with that, I'm going to start with Dr. Rouyer. So, it's good to see you again virtually, you know, albeit we saw you in person a couple of weeks ago.

MS. ROUYER: Sorry for that.

COMMISSIONER WRIGHT: Yeah. So, I understand that the Joint Safety Research Project meetings were held earlier this year. And, you mentioned that the NRC participates in a number of joint projects that are managed by the NEA Secretariate.

Talk to me a little bit about how the topics for these joint projects are selected. Is it largely driven by research staff? Or, is it technical support organizations? Or deregulatory staff? And maybe even Commissioners have a say?

MS. ROUYER: Thank you. Thank you, Commissioner Wright. This is an excellent -- sorry, can you hear me?

COMMISSIONER WRIGHT: Yes.

MS. ROUYER: It is an excellent question. Because of course we cannot do everything. And, you cannot do everything. And so, we have -- and it's also true at the international level. And so, we have to prioritize.

So, the NEA has an experience on this type of issue with these tools that are joint projects. The first point of course, it's obvious, is to identify the needs and the tendencies. For that, we need to -- the best tool is really dialogue between all the stakeholders. You know, and not only researchers, not only technical support organizations, and that of course the regulators, and industry and so on. I mentioned that in the presentation.

And, the point is to have a dialogue that is well structured and organized between the stakeholders, to try to be able to get the sense of the events. And, at the international level, we are trying to do that in a few frameworks, like the Committee on the Safety of Nuclear Installations Working Group. And then, we are -- we base our first thought on benchmarking, round robins, technical reports, but also the workshops as I mentioned before.

It could be also the initiative of one, of one partner that would like to investigate more an issue. I take the example of recently a workshop has been focused on harvesting issues. And after that, why not the idea to develop the framework recovery team on harvesting material research activities all over the world. Because in different countries now, we have several activities around this topic. And, if we in particular is strongly involved in this, it's like with lead position.

So, this is -- this is the first thing, to organize and structure the dialogue on the priorities. And, based on the material, reports, and so on. The second part is to identify a potential leader. If you have no leader, you have no project. And, you need a leader and partnerships. And, the leader could be different. In our case, it is often the regulator or the technical support organization. But, it could be also the operating agent, especially in case of experimental research activities.

And that is an inquiry, the point I mentioned previously in my presentation, about research capability availabilities that are critical. It is important to have a discussion for these facilities or for these capabilities on long term perspective. To maintain these critical facilities and also, perhaps to adapt these tools. And, this is -- this is in what several groups have been doing in the framework of FIDES.

The partnership identified not only the need, but identified the need to maintain the capability in terms of research the facilities or what was needed. And, with that, the operating agent themselves can propose, can propose different things, consider -- taking into consideration also what they can do. And, when is it the right time to do that, what kind of opportunity they have. And, this is a way also to -- well, it is a point to consider in the decision of applying new topics.

And, the third point that has to consider, is the fully, the need to optimize the projects. So, this is something that, well, at the NEA we try to push in this direction as well. Optimize that is to say, prepare the dialogue, prepare the proposal, manage people through discussions, benchmarks, and so on. Just because these projects are very expensive. Well, advanced for some of them. So, we have to see if we can focus on different phases in a more optimized way. And, this is a way also to select or to discuss the priorities.

COMMISSIONER WRIGHT: Thank you so much. Dr. Mohaghegh, I want to follow up a little bit. But, maybe a little, in different way on the questions that Chair Hanson asked you a little bit.

So, obviously research can't happen without people. Right? And, so, I'm going to go a little deeper on a question, maybe from a different direction. I've heard around that, you know, we've got money in some of these universities around the country, but we don't have people, we don't have students that are getting into the programs. Right? And, I mean, I've heard AI may be an area. I've heard you know, health physicists. You know, those programs are areas.

So, I mean, if it's -- if it's a thing, right, that that's happening, how do we attract more students into the programs that the university nuclear leadership research programs support? Right, how do we do that? Do you have any thoughts?

DR. MOHAGHEGH: So, I personally don't think that a specific topic, for example, whether computational research versus experimental research, one of them could attract more. In my opinion, again, it matters that the student ssee the impact of their research. That matters to them a lot.

And, that's why, in my opinion, that for example, generating these types of centers and initiatives, that directly work on the topics that NRC needs right now, I think will be very, very valuable for a student, because they think that this topic definitely, if they work on that, it will be used immediately by the Agency.

In my view, if students see these types of centers and initiatives directly to address regulatory agency's needs, significantly increase the number of students in nuclear engineering.

COMMISSIONER WRIGHT: Okay. All right. Thank you. And, I notice that you've got a course, maybe several courses on PRA. Right?

DR. MOHAGHEGH: Yes.

COMMISSIONER WRIGHT: And, I know that some universities have had a difficult time finding instructors to teach PRA, especially ones with real world experience. Right?

DR. MOHAGHEGH: That's right.

COMMISSIONER WRIGHT: Has that been a challenge for you all? And, if it has been, how did you, how did you overcome it?

DR. MOHAGHEGH: Yes. I joined the University of Illinois in 2013 and established this area at the University. I think half of the nuclear engineering in the country don't have a PRA course at all. The rest of that, they have PRA as a technical elective. And, almost, I believe, two only have as a required course.

And, that says something very important. That nuclear engineers go to the workforce without having any understanding of probability and risk. And, when it comes to the application of real world, there is lack of tendency to utilize a risk informed approach, because of the lack of knowledge about that, in my view.

So, in my view, it's very important that we put the PRA as a required course in the curriculum of nuclear engineering in order to down there, the workforce is comfortable to utilize. So again, my perspective on risk probably is biased. But, I do repeat to my colleague, we don't want to repeat the history before WASH-14. We didn't have any data, and we felt that it's safe. But, after WASH-14, there's also the WASH-1400 actually showed vulnerability of safe design.

But, now again, we're dealing with the same thing, I think. I do believe that there's a high premise of safety for advanced reactors. But, there are a lot of unknown unknowns, and PRA significantly could help in order to find the answer to a lot of whys and uncertainty in the underlying assumption. Maximum hypothetical accident, are based on assumptions, exposed to uncertainty. Without doing PRA, we won't be able to answer to that question.

So, in my view, the lack of knowledge about PRA is one source of that. And, if you put in the curriculum, that helps. Second, I think we need to invest on developing methodologies. So, research on risk informed tools and methodology facilitate the usage of that for developers, if you generate these methodologies and that are endorsed by NRC. I think that's easy for all the stakeholders to use that. So, I do think that education of the PRA matters.

COMMISSIONER WRIGHT: Thank you.

DR. MOHAGHEGH: Sure.

CHAIR HANSON: Thank you, Commissioner Wright. Commissioner Caputo?

COMMISSIONER CAPUTO: Good morning. Thank you all for joining us. I appreciate hearing your insights and your expertise. It's been interesting to learn how each of your organizations have programs and activities to tackle some of the same issues that we are looking at here at the NRC, and learning about bridging knowledge and skill gaps, conducting research to make risk informed decisions, and addressing key technical issues.

One of my main concerns, when it comes to research projects is that they start with an objective of finding a solution to a problem. But end up having, identifying problems and questions that seek further precision in pursuit of further risk reduction.

As I said during my speech at our Regulatory Information Conference, how we balance a constant desire to know more with the threshold of knowing enough. Which gets, I think, to some of what Dr. Mohaghegh was just talking about.

Is our ability to model minute risks driving the pursuit of absolute safety rather than adequate safety? How do we balance the constant desire to know more with the constant threshold of knowing enough?

As responsible regulators, I believe we should focus our research on projects with a finite end that are prioritized based on safety significance just from the very start of our research endeavor.

So, I'm going to start with a question to the panel, although I'll start with Dr. Rouyer. There's a lot of research going on, both research into the science and technology and phenomena. But, there's a category of research that has to be done with regard to safety and regulatory confidence. So, in the context of what your organizations are doing and your experience, where do you see the biggest challenges in safety research with regards to ensuring regulatory readiness and confidence in advanced reactor technologies? Dr. Rouyer?

MS. ROUYER: Yes, thank you. Thank you for the question. It's a difficult question. About your thought about knowing more, knowing enough, and things like that as well. We discussed this previously this risk-informed topic, which is very important for me, I think.

And, even in this consideration, what I try to, but I write in my presentation, is that the objective, of course, is to know, I would say, better. Know more and I think it is more of a better. That is to say, to better know the uncertainties. And, it is also a way to maintain the competencies. Because it is a key point. You can consider it, you know, enough. But, you have to be sure that you know when. That is to say, you know exactly why it is enough. Why, you know, exactly what the data are, what the, why these tools are enough developed. And, for that you have to maintain outcome, the scientific activity.

And, to maintain that you need a motivation. And, the motivation for me at this point is perhaps to better know about the uncertainties of that. And, it is, I think, one of the roles of the safety research, if we talk about safety research, or research focused on safety. Now, to know how much you have to do, that's another question. It is often driven by also the ability to maintain capabilities.

And, if you would like to develop new designs, new innovative models, new methodologies, you have to be ready, you have to have the capabilities to do that. And, if you don't maintain research activity, the risk is that it will spend a lot of time issuing just an additional, I would say, or different information.

So, while it is a -- I'm not sure I'm happy with this answer completely. But, I think it is really what I think. I think what in my past, I had exactly the same issue, of how to balance the result that we have to put in research activities. And, the focus I had always in mind to maintain the competencies. And, it's not easy to build competencies. So, we have to take care of it.

COMMISSIONER CAPUTO: Okay. Thank you. Dr. Shafer, you mentioned a couple of times this morning, trust and machine learning. That really ends up, I think, to a large extent being a cultural issue for us here at the NRC. Can you just address that a little bit in terms of the challenge? In terms of how we do our research or how we prioritize our research to reach the answers we need?

DR. SHAFER: Yeah. I think that that's a great question. And, I think that it is partially cultural. And, I think it also partially goes to kind of the deterministic versus some other approaches there.

But, you know, from what I've seen with respect to the development of AI machine learning technologies, I think part of it is validation of them in a variety of different ways, is really one of the most critical ways to develop that and work with that.

And, part of why I emphasized especially NRC potentially developing technologies or programs looking at this, is I feel like we -- right, I'm running a reprocessing program right now. And, I've had conversations with others at the NRC about these technologies and in looking at this and trying to understand it.

I feel like foundationally the questions that exist with respect to reprocessing technologies, are different than what we're dealing with, with respect to AI machine learning technologies. And, maybe as we come to learn more about reprocessing and as the NRC is working with it, maybe they'll develop specific questions where they want to understand more. But, part of it is, I think, as technologies are actually being researched by the NRC, this will develop more familiarity with them from the get-go, with respect to understanding of how they operate, understanding the particular failure modes. And, I think that this is part of why I've identified this a couple of different times. And, I don't know that there's a good way that that can be developed, you know, just by kind of talking to people externally. So, that was one reason why I was emphasizing that there. Hopefully that can somehow answer your question.

COMMISSIONER CAPUTO: I do. I do think that, like you said, some of this has to do with how much research we do, and how much familiarity we develop over a period of time with the technology. But, I think for us, particularly when it comes to machine learning, you know, we have wrestled with digital instrumentation and control for decades. And, I'm concerned that we will face a similar cultural challenge when it comes to embracing these newer approaches. But, Dr. Shafer, I have another question for you.

DR. SHAFER: Sure.

COMMISSIONER CAPUTO: I noticed in your slide on GEMINA, that you are looking to arrive at an O&M goal of $2.00 a megawatt-hour.

DR. SHAFER: Right.

COMMISSIONER CAPUTO: I would have thought decreasing O&M costs to -- by half, would be a striking achievement. And yet, you've set the goal at $2.00. What was the -- what was the basis? How did you folks arrive at that as an objective?

DR. SHAFER: So, the goal for this at the time it was set up, so Rachel Slaybaugh was the previous Program Director and issued the program. And, I thought she had a great bold vision for this when I inherited it. But, it was really to be cost competitive with combined cycle natural gas. It was basically setting the bar that this is where we need to go if we're going to be effective as a nuclear industry.

And, I think we've had some outreach with performers and some of our teams that even just kind of how things are structured in the regulatory space. That, you know, just on regulatory fees alone, it's possible that we may not be able to hit that $2.00 a megawatt-hour. Especially, if you combine kind of the uncertainty of, you know, as some of these technologies are set up with respect to O&M, or actually sorry, AI machine learning based infrastructure, right, that also adds a regulatory uncertainty with how that might be needed to be costed and assessed, et cetera. But, so that was basically the driver for the $2.00 a megawatt-hour.

COMMISSIONER CAPUTO: Okay. Thank you. I have one last quick question for Mike. Fuel qualification, obviously in a regulatory context, is pretty important. And, one thing I think that I've noted over time is just, there can be a difference between the quality assurance regime that DOE uses by and large, and some differences with QA Program that we have here.

And, I'm just wondering, are you confident that the work that's going on with fuel qualification for advanced reactors is going to recognize those differences and make sure that the data being collected is going to meet our requirements when the applications are coming in?

DR. GOFF: On our programs on the advanced reactors, they you know, I wouldn't say, they RDPed demos and all. I mean, that goal is set up to, it's NRC license. So, I mean, from the start that pro -- you know, for the demos, the X-energy and the Natrium 1, is it's always been the goal NRC license.

So yes, I recognize we do have some differences between DOE and NRC. But that's always been set up that it's going along toward NRC licensing even though they may be doing the testing at DOE, they should be using NQA-1 standards for the qualification for that.

So, we will have some tests on the risk reduction side that may be under DOE authorization. But, they are a little bit further out and will require some additional work to get that to the NRC.

COMMISSIONER CAPUTO: Okay. All right.

Wonderful. Thanks, always good to see you.

CHAIR HANSON: Thank you. Commissioner Crowell?

COMMISSIONER CROWELL: Thank you, Mr. Chair. And, thanks to all our presenters for being here today. I think we've answered a lot of questions and raised a lot of questions and learned a lot along the way. So, I appreciate it. I also wanted to thank Commissioner Caputo for proposing that we have this meeting today. I think it's, for the same reason, it's been very enlightening.

I'm going last, so perhaps it's to no one's surprise that I'm going to focus on the back end of the fuel cycle for the most part on my questions. But, before I get there, I just, Dr. Shafer, I know you're getting a lot of airtime. I'm going to give you some back here again.

But, you know, I always love to hear from ARPA-E. You always blow my mind in some way. Today I think you did it with your turn signal anecdote, which is music to my ears.

You also mentioned that, you know, for advanced reactors there's no clear pathway to disposal. I'd argue that probably for any waste stream there is no clear pathway to disposal, but particularly for high-level waste streams. So, we need to focus on all of it and try to solve all of it. But, your very last slide, Dr. Shafer, you said, if it works, will it matter? Can you explain what you mean by that?

DR. SHAFER: Sure. And, I would agree with you that we don't have a particularly clear pathway to, in many ways streams of disposal, what that might be. What I meant with respect to ONWARDS is that there are technical, very unclear technical challenges with respect to how to dispose of some of those fuel forms.

But, so with respect to if it works will it matter, so this is the ARPA-E slogan that we have. And, it's based certainly a monster that we have, if you want to say it in the office, of trying to focus on, if we do the research, will it get deployed?

And so, this has a significant part of why we have our tech to market arm. And, in fact, DARPA, you know, has actually, we cobble a lot of things from DARPA. And one of those things that DARPA has cobbled from us is actually have a real tech to market focus on some of the things that they are doing. So, basically it's making sure if we select something, will it have market viability and will it get out the door? So, happy to expand on that more if you're curious.

COMMISSIONER CROWELL: That's helpful. And, it's enough for me to transition to what was going to be my next question. Which is, you know, who does it matter to? And, I think part of the answer to that question is, you know, the next stage on the R&D ladder, which is, I guess, maybe starts to head into your shop, Dr. Goff, at NE.

But, you know, hopefully ARPA-E is doing things that are, make a material difference to the work that NE does. And, could you talk a little bit more about how, if and how ARPA-E and NE work together on these, the bigger picture solutions?

DR. SHAFER: Sure. Absolutely. Happy to do that. And, Mike, feel free to edit or amend anything that I say here.

You know, as far back when Rachel Slaybaugh joined in 2017, and working with NE in trying to identify white spaces of technologies that, you know, maybe aren't quite on the NE roadmap. But, if we were maybe able to start looking at them, be risking them, this might be something that eventually an agency like NE, or frankly, other parties might end up taking on. ARPA-E spends a lot of time thinking about what is the commercial sector interested in? What might the government eventually be interested and available to look at? And so, that's how that sets up.

And so, when we were looking at, I wasn't a part of these conversations as much. But, I understand that when we were working on MEITNER and GEMINA, right, there was interaction between what ARPA-E was doing as well as NE at the time, to make sure that we were dovetailing well with the broader NE efforts as well as goals.

And then when it comes to, you know, the efforts that we've been doing now with respect to ONWARDS, you know, at the time there wasn't as much waste research focused on advanced reactors. And so, this was kind of an opportunity where we looked at it and considering some of the technical challenges that exist in that, we said, this is a place where we could start seeding the conversations. And, based on this, that might actually be enabling with respect to how NE is able to potentially further mold their roadmaps.

And then when it comes to the reprocessing technologies, we've had wonderful conversations with folks in NE to understand how this dovetails with their, they have a fuel cycle campaign. I was funded by it for many years, right. How it focuses on what they're working on. And, how the specific technologies that we're looking at might also perhaps mold future roadmaps.

But, they're of course no way beholden to take on what we do in any way. But, just trying to think about if we look at this, this is something that they might be eventually interested in picking parts of and continuing. And then, would you like to add anything Mike?

DR. GOFF: Yeah. I'll just reiterate what Jen said. I think there has been good coordination. Whether it's the work on the fuel cycle side, they will sit down with our Deputy Assistant Secretary for the fuel side on supply chain they will talk about the call beforehand. You know, make sure again it's not duplicating.

So yeah, there is good synergy and discussions on what they're putting out for a call and what, you know, we you know, making sure we're not overlapping there as well.

And, I'll also note, there's also a reasonably good coordination as well with our National Nuclear Security folks that work in the nonproliferation area too, coordinating with them as well, the different activities, you know, among all our three groups there have, so.

COMMISSIONER CROWELL: And, that's great to hear. And, let's stick with you here with transition to work cooperation. But, specifically in one of your slides you mentioned, you know, restarting meetings, I think, with NRC on used fuel recycling. And, I'm just curious if you can elaborate a little bit more on any specific topics within that context that you're thinking about, the restarting the meetings.

DR. GOFF: On the fuel side what I was mainly taking about was, we will have more on the -- this is more front end side. I mean, we have had discussions at times on, you know, as we're looking at going forward with consent-based siting type activities and all.

I think what I was referencing there though we are looking at very -- we did have funding under the Inflation Reduction Act to move forward on stimulating capacity for high assay low enriched uranium capability. As we do that, as we go out and do something that will involve a commercial enterprise as going forward and putting forth new capacity, we will have interactions as far as on the NEPA coverage on that. What activities we do coordinated with what activities industry will be doing through you and all as well. So, we will be having a lot more interactions on that as we look at trying to spur that commercial capacity there as well, so.

COMMISSIONER CROWELL: Gotcha. And, you know, you mentioned that multiple addendum to that NRC DOE MOU, which is great to see that it's a, you know, a living document that is trying to capture the full breadth of the challenge ahead of us. And, it kind of, the most recent addendum, you know, mentions back end of the fuel cycle. But, is there specific work under the NRC DOE MOU on the back end of the fuel cycle?

DR. GOFF: I think there's more coordination. Like I say, we are right now looking at trying to potentially assess going forward with an interim, a federal interim storage facility. We have funding to at least look at that concept going forward. Obviously, we are constrained by the Nuclear

Waste Policy Act on what we can and can't do.

So, we are looking forward at potentially going forward on those. The things we're doing right now, which I think would be good to continue to coordinate on, we are looking -- we have put out a solicitation and received input on for more community involvement on how we can go forward on a consent-based process with communities on various waste issues.

So, we have had that solicitation go out. They're under evaluation now. We hope to do some awards on that in the near term. Coordination with you under those type of activities as we go forward, I think, would be a bit beneficial.

COMMISSIONER CROWELL: Yeah. I agree. I think it's not always just technical research topics that we need to coordinate on. There are also, you know, social and public engagement research, you know, endeavors.

That being said, Dr. Pickett, I think the role of the research center is more important now than ever. Particularly with respect to fuel management in the back end of the fuel cycle. And, I've made a big point in my short time on the Commission of, you know, if we're going to be looking at a build out of new nuclear power in the United States for energy security, climate change, whichever reason you choose, we need to be making as much commensurate progress as we can on fuel management in the back end of the fuel cycle.

They don't want to solve one problem, and you know, create another at the same time in terms of managed fuel. So, I noticed your research, part of the research needs on the last page there, are those -- is that a wish list? Or are those things you have some traction on with one entity or another in hopefully getting started or are that already started?

DR. PICKETT: Well, it's primarily a wish list. But, certainly, you know, at least in terms of the center, we have started looking at advanced reactor fuels over the last couple of years.

So, I -- you know, so far not only a small amount with respect to disposal. But, we have some capabilities in some of these other areas. But, I mean, I agree with you that when it comes to ultimate disposal, for example, it could be very helpful to spend some more time thinking about how these fuels and their associated waste would be disposed of, because that could provide a feedback into design, into optimizing how you design these reactors and design these fuels, so.

COMMISSIONER CROWELL: Okay. I look forward to talking about that more. And, Mr. Chair, if you'd indulge me for one more quick question. Mr. Chengelis, just to make sure you're still awake, because we've left you out of this conversation a little bit. But, curious to know what EPRI is doing, or EPRI is doing in coordination with NEI.

So, what is the industry doing to be focused also on the back end of the fuel cycle and fuel management, recycling, disposal. Could you speak to any collaboration that's happening there?

MR. CHENGELIS: Yes. Thank you for the question. And still awake and enjoying the conversations. Yeah. So, we are focusing on that with NEI. It's actually part of the roadmap. It's one of our strategic areas. So, we have 13 diverse strategic areas. The fuel cycle would be one of them as well and the back end of the fuel cycle.

Also, we, EPRI is involved in the CURIE project that was mentioned earlier in one of the presentations. So, yeah, we agree with a lot of the discussion that was had today. That is a big part going forward, how do we dispose of the waste both current and what's going to be produced as we continue to build out new nuclear. So, yes, it's going to be a key focus area for us and as part of that NEI roadmap as well. And, yeah, a lot of focus around the area both.

COMMISSIONER CROWELL: Great. Thank you. Thank you, Mr. Chair.

CHAIR HANSON: Thank you, Commissioner Crowell, and thank you again to our external panel. I really appreciate the conversation, both the folks who joined us here in the room, as well as our participants online. Thank you. We're going to take a break until, let's say 10:55, and we'll reconvene with the staff panel. Thank you all.

(Whereupon, the above-entitled matter went off the record at 10:47 a.m. and resumed at 10:57 a.m.)

CHAIR HANSON: Our next panel will be kicked off by the NRC's Deputy Director for Materials, Waste, Research, State, Tribal, Compliance, Administration, and Human Capital, all the things -- (Laughter.) -- our very own Cathy Haney. Cathy, the floor is yours.

MS. HANEY: Well, thank you very much, and good morning, Chair and Commissioners. We're here today to update you on the regulatory research activities which are vital for agency preparedness for the changing landscape in the reactors and the materials programs.

The Office of Nuclear Regulatory Research is positioned to deliver on our agency vision of being a modern, risk-informed regulator with a skilled, adaptable, and engaged workforce that promotes diversity, inclusion, and innovation. Through research and collaboration with domestic and international partners, our Office of Research provides the technical expertise and analytical tools necessary to support programs across the agency and drive innovation.

I'd like to now introduce you to the panelists who will talk about the agency's regulatory research activities. First, Ray Furstenau, who is the Director of the Office of Nuclear Regulatory Research, will provide an overview of the research program and discuss international research engagement and future-focused research.

Mike Franovich, to my right, is the Director of the Division of Risk Assessment in the Office of Nuclear Reactor Regulation, and he will present on the research contributions to mission success and technical basis development to support regulatory decisions.

Moving to my left, Fred Sock, a structural engineer in the Division of Engineering from Research will discuss cooperation and benefits of involvement with the National Reactor Innovation Center.

Continuing to my left is Louise Lund, who is the Director of the Division of Engineering from Research, and she will discuss enhancing the research program through stakeholder outreach.

And then finally, Tom Boyce, who is the Chief of the Materials and Structural Branch from the Office of Nuclear Material Safety and Safeguards, will present on fuel cycle research cooperation. This concludes my opening remarks and I'd like to hand it over to Ray.

MR. FURSTENAU: All right, thanks, Cathy. Good morning, Chair and Commissioners. Thanks. Thanks for the reminder. It's a pleasure to be here today to talk about all of our research activities and how we're helping the agency to be ready to regulate innovative nuclear technologies.

Before I start, I remembered during the RIC, Chair, you had always had Einstein quotes, so I said I'd better have an Einstein quote about research, and then I found one. If we knew what we were doing, it wouldn't be research. I'm not so sure that's the best quote to use for this meeting --

(Laughter.) -- but it is an Einstein quote, so I'll leave it at that.

And I also wanted to acknowledge Louise Lund, who is on the panel. She's retiring at the end of April with over 27 years or close to 27 years of service to the NRC, so thank you for that, Louise. So, okay, so next slide, please.

Yeah, our research capabilities, of course, begin with our talented staff. The Office of Nuclear Regulatory Research is composed of staff with, I think, world class expertise. Over 60 percent of our staff hold advanced degrees. I've spent the majority of my career involved with research activities, of course here with DOE and here at the NRC, and I think our team compares with the best at the labs, and so I'm really proud of that.

They're really some of the best I've ever seen and they really assist our agency in solving many of our most challenging safety and security questions, so my thanks to the staff.

We also, as we look ahead, we also, our future staff needs, we host about 15 summer interns each year in the Office of Research, and several of them then convert to co-ops and a lot continue with full-time employment at the NRC. That's always a good program to kind of test drive people that might be interested in coming to the NRC.

As part of our capabilities, our office also develops and maintains a suite of computer codes to support our confirmatory analysis and technical basis for NRC's regulatory decisions.

Finally, depending on the extent and duration of the need for technical capability, we can either develop an in-house or leverage external capabilities. It's kind of a make-and-buy decision depending if it's at a short-term need or a long-term need.

An example of this, next month, we're going to have an IPA, that's an intergovernmental personnel assignment, from the Idaho National Lab, who has experience in metal fuel code development, and that's an area where we see some need, and he's going to be helping us model metallic fuel into our fuel performance code FAST, so that's an example of that.

Really, when we get expertise from national labs, FFRDCs, and commercial contractors, as well as universities, it really helps us maintain that right balance of internal and external expertise to help us be ready. Next slide, please.

A key to delivering useful research results is, of course, strong engagement with our internal partners in NRR and NMSS, and you'll hear from Mike and Tom later in this panel about that. These strong partnerships really us set the priorities for our research investments and helps ensure we are developing responsive products at the right time.

Similarly, we also rely on and benefit from our external partners like DOE, EPRI, universities who were represented on the last panel, and others who we collaborate with and contribute to research results analysis, including our international partnerships.

On the international side, you heard about that in the previous panel as well. Our office collaborates with multiple countries through the Nuclear Energy Agency to conduct research that the U.S., or any other country for that matter, really couldn't easily be able to support it alone. You heard about the FIDES project, for example, and we participate in that joint project. I happen to be the Chair of the Governing Board for that, and I really look to our staff to do leadership roles in those joint projects and working groups, because if you don't participate, you can't influence. And so, I think it's important to be involved in the international partnerships, and particularly in the joint projects because I think they're an excellent value and it's really an important way to get those, help fill those data gaps to help take some of the uncertainty out of the modeling and simulation codes.

Besides the FIDES project, we also participate in a joint project where we're the operating agent, that's the rod bundle heat transfer facility, and the testing that's being done through NEA. It's located at Penn

State University and we help sponsor that, and both FIDES and the RBHT are good examples of getting that extra data to help reduce uncertainties in our fuel and thermal hydraulic performance analysis, just as examples.

Another example of our officer's global reach is our computer codes, and we have over 10,000 users that participate in those code user groups, RAMP, CAMP, and CSARP, and it really brings together experts from around the world that can collaborate on the development and improvement of those codes. Each user group has about 15 to 30 participating countries and the communities of those users participate with in-kind contributions to the improvement and use of those codes. And these user groups access the well-known codes we use, MELCOR, TRACE, and SCALE, for example, and we'll share some ways NRC uses those codes here later on. Next slide, please.

I wanted to spend the last few minutes of my time about the two newer programs that our office leads that are really quite exciting for me and really do have the potential to keep us at the forefront of understanding and preparing the agency to be ready for emerging technologies. Those are the Future-Focused Research program, which is an internal program, and as well as the university programs.

First, the FFR program, it was launched in FY20. The Commission supported us with a start in FY20 and it continues to this day. It really aims at encouraging staff ideas, and promoting research innovation, and identifying where the future trends and regulatory needs might be. I kind of, when we got started, I kind of compared it to a national lab-directed research and development program, but it's really at a much, much smaller scale than that, but to try to get ideas and staff, I mean, keep them enthused about the work that we're doing at the NRC.

So, since FY20, we've funded 24 projects. Not all of them are expected to result in successful applications, but we, I think we have seen benefits out of many of these innovative projects. For example, the two successful projects I'd just like to briefly mention are the digital twins project, which began in FY20 and I've produced several reports supporting regulatory implications for that technology, and remote operations, which started in FY21 and also produced a paper.

Later this summer, we're performing a lessons learned assessment of our FFR program to help us determine where we can improve that program, and we also need to develop better performance metrics to really help us measure is this program effective and is it going where we want it to go?

The other program I wanted to mention was the university grants, R&D grants program, which was talked about at the last panel as well, and it really supports mission-related R&D activities. That also began in FY20. It hasn't always been in the university program portfolio that we had, but since we started it, we've awarded $23 million to 46 R&D grants under the University Nuclear Leadership Program and we're starting to see results from this program, and we're working with NRC to keep NRC staff informed of these university activities through seminar presentations with staff.

And kind of like with the FFR program, I think we need to, as we go forward with the newer program, to develop some better performance metrics to really see, okay, is it effective? Do we need to make changes to it to improve the program?

So, my overall goal for this is to really make the universities' R&D grant program and the Future-Focused Research Program more complementary of each other. Both programs focus more on this anticipatory research to support our missions, and going forward, we plan to increase the visibility of FFR activities to the universities which may provide opportunities to share ideas and improve interactions.

In summary, I think both programs are important for enabling the use of advanced nuclear technologies, helps NRC staff stay at the forefront of emerging technologies, and supports our nation through the development of the future workforce. That concludes my remarks and I'm pleased to turn it over to Mike.

MR. FRANOVICH: Thank you, Ray. I'm Mike Franovich, Director of the Division of Risk Assessment at NRR, and this morning, I'm going to cover where research has actually supported my division in NRR to meet our mission and to provide the technical bases and reliable regulations. Can I go to slide nine, please? Thank you.

Research helps NRR make better decisions. A primary example is the SPAR-DASH project the Commission was briefed on in detail last summer. SPAR-DASH is an interface tool that increases staff accessibility to risk information beyond the risk analyst community.

Launched in January of 2022, the SPAR-DASH project has an easy to use and interactive dashboard format and facilitates and also enables communication of risk insights, and also supports our Be riskSMART framework.

SPAR-DASH uses the agency's SPAR models, which are the NRC's independent probabilistic risk assessment models for each operating facility. SPAR models enable agile analysis. Analysis may involve emerging safety issues, review of licensing actions, or determination of the significance of inspection findings.

SPAR models have been upgraded to reflect the post-Fukushima mitigating strategies for beyond design basis events, and also for plants that have transitioned to NFPA-805 fire protection programs, many of these capital upgrades have been reflected in the SPAR models.

On a plant specific level, we can now quantify with more confidence the risk reductions achieved and extract risk insights from the benefits of these major improvements. We have observed marked reductions in significance of certain inspection findings and plant events. In some cases, the risks have been lowered by almost an order of magnitude because of these improvements.

For example, we assessed the 2020 derecho event at the Duane Arnold plant, and completed a focused assessment of similarly situated facilities as a potential emerging safety issue. SPAR models provided a base capability to assess the combined effects of powerful straight line winds and resultant debris. Storm-generated debris could degrade service water cooling of a plant during an extended loss of offsite power event. As a result, no new regulatory requirements were warranted. However, by using the Be riskSMART framework, we boosted our stakeholder outreach to share this important operating experience. Next slide, please.

By applying the experts' research knowledge, we have resolved challenging licensing issues. For example, a key issue for small modular reactors has been establishing an appropriately-sized emergency planning zone. The size of an EPZ impacts aspects of emergency preparedness, coordination, and planning required among different states, counties, school systems, medical facilities, federal entities, and other organizations.

In 2022, we successfully resolved intricate EPZ-related issues for rare earthquakes and other hazards for a multi-module facility. More specifically, we used a risk-informed approach and modern consequence analysis techniques as applied to the unique features of the NuScale design. Research staff provided expertise with NRR's examination of the consistency of the methodology described in NuScale's topical report and compared it with the methodology from the technical basis for the current ten-mile EPZ. We approved NuScale's topical report for EPZ sizing of a radiation plume exposure pathway specific to a NuScale facility. The result was a technically defensible regulatory decision consistent with the principles of risk-informed decision making. Conceptually, the technical approach has the potential to be leveraged for other new and advanced reactors. Next slide, please.

So, research has been foundational to reliable regulations.

Substantial evaluation of acts in the phenomena and the offsite consequences of severe reactor accidents has occurred over the last several decades. I think you've heard quite a bit of that from the previous panel as well.

The Department of Energy, EPRI, and other international stakeholders have worked closely with the NRC to develop expertise and analytical tools. Two key codes embody this extensive severe accident research and expert knowledge that shapes our work today, namely, the MELCOR code which assesses severe accident progression, and the MELCOR acts in a consequence code system commonly referred to as MACCS, models the offsite consequences in terms of health effect risks and potential impacts. Both of these codes are extensively used in the U.S. and internationally. After the events of 9/11, the Commission directed that a 21st century consequence study be performed to apply the best research information available for a more realistic assessment of severe accidents. Hence, the NRC completed the SOARCA project using these codes. SOARCA comprised a major study of three U.S. facilities.

We have applied the insights from the SOARCA study. The most recent example is the ongoing license renewal Part 51 GEIS rulemaking. More specifically, SOARCA has shaped proposed treatment of severe accident mitigation alternatives for subsequent license renewal work. This modern consequence analysis capability contributes significant to the completion of the ongoing Level 3 PRA project. We envision similar benefits to agency activities from the Level 3 PRA project as those achieved through the SOARCA project.

And lastly, I'll note regarding MELCOR and MACCS, these codes support a multitude of regulatory activities. For example, the staff completed a rigorous analysis of the post-Fukushima FLEX strategies to mitigate BWR severe accident consequences compared with additional filtration systems. Using MELCOR and MACCS, these realistic assessments with BWR FLEX strategies and severe accident capable hardened vents were determined to be sufficient. Hence, the proposed BWR containment protection and release reduction rulemaking was terminated.

For new reactor design certification, the staff has also created MELCOR decks for independent confirmatory analysis of the AP1000, ESBWR, and the NuScale SMR design. The NRC's investment in MELCOR and MACCS has been pivotal to the support of present-day issues as well.

Source term characterization is an ongoing topical area for accident tolerant fuel, high burnup levels, and the increased enrichment rulemaking. The NRC has also conducted workshops using MELCOR and MACCS for non-light water reactors. This concludes my remarks. I'll now turn it over to Fred for his presentation.

MR. SOCK: Thank you, Mike. Good morning, Chair Hanson and Commissioners. I'm Frederick Sock, a structural engineer in the Office of Research, Division of Engineering, Structural, Geotechnical, and Seismic Engineering Branch. I will be briefly discussing our research engagements with our partner at the Department of Energy's Idaho National Laboratory, specifically, with a team from the National Reactor Innovation Center, otherwise known as NRIC. Next slide, please.

As Dr. Goff mentioned earlier this morning, an addendum to an MOU on nuclear energy innovation was signed between DOE and NRC back in February 2021 that offers two NRC staff members the opportunity to be on a rotation with NRIC; I'm one of those two members. The whole idea behind this collaboration is to improve NRC's technical readiness for advanced nuclear reactor applications.

Under a public-private partnership, the Advanced Construction Technology Initiative, also known as ACT, was launched by DOE to NRIC to design and build a scaled-down version of the first two levels of the reactor building of a small modular reactor as shown here. Next slide, please.

This collaboration is mutually beneficial to both NRC and INL as it provides the NRC staff an opportunity to participate in this demonstration project and to evaluate the inspection and acceptance criteria the staff are currently using, and if needed, update current NRC inspection manuals and procedure as part of the Advanced Reactor Construction Oversight Program. All of this is done while maintaining NRC's regulatory independence. For INL, the presence of the NRC staff members in the NRIC program allows for the seamless connection of NRIC team members to all of the expertise at the NRC. Next slide, please.

The ACT demonstration project aims to study the use of three advanced construction technologies that have never been used before in new nuclear builds and which have the potential to reduce costs and schedule. The first of these three technologies is the use of vertical shaft construction techniques shown here on this slide. On the left is the vertical shaft sinking machine and on the right is the conventional vertical shaft excavation method for the use of sinking piles. These techniques will avoid over-excavation of the nuclear island foundation and the placement of engineered backfill, thus reducing costs and schedule. Next slide, please.

The second of these new technologies is the use of the trademarked Steel Brick system for the major structural components of the seismic Category 1 structures, including the reactor and containment buildings. Steel Bricks are enhanced steel-plated composite or SC structural elements that have all of the advantages of composite construction such as eliminating form work and rebar installation while minimizing the disadvantages, such as integration of SC modules to the basemat. Next slide, please.

The third and final technology relates to the condition and performance monitoring of embedded structures, constructive and Steel Brick modules, the many construction and in-service surveillance programs defined in 10 CFR 50.65, regulatory instruction of monitoring requirement.

To help mitigate potential costs and schedule overruns, a digital twin model of the scale structure shown to the right of the slide has been developed that will be used to monitor the scale structure's behavior and to gather critical design information through all stages of the project from initial component fabrication to the decommissioning of the project. I thank you for putting up with me and I now hand it over to Louise Lund.

MS. LUND: Thank you, Fred. Good morning, Chair and Commissioners. I'm Louise Lund, Director of the Division of Engineering.

Next slide, please.

Our agency's strategic plan has an objective of engaging stakeholders in an effective and transparent manner to increase stakeholder confidence and uphold high quality safety, security, and safeguards standards, and technical proficiency. Our stakeholder outreach in the Office of Research is a key component of fulfilling this aspect of the strategic plan. We engage in proactive and meaningful interactions, both domestically and internationally, as you've heard from our external panel, and we really appreciate our interactions with them.

The 60 organizations indicated on this plot provide a representative, but not comprehensive view of the organizations we engage with. Research casts a wide net to ensure comprehensive and extensive stakeholder engagement and cooperation with government, research laboratories, universities, industry, international organizations, some of which you've heard from.

This enables the limited resources of the research program to be leveraged to accomplish mission-critical research on behalf of the program offices. We work together to gather data, but each organization evaluates the data independently. Research leverages funding, but also expertise and capabilities of outside organizations to help accomplish our mission, especially in areas that are new and complex.

We provide technical leadership where appropriate in the activities of the IAEA and NEA, as well as in domestic research activities in codes and standards. We benefit from technical networks formed from long-term relationships to better understand complex technical issues, access data in a timely way, and position the program offices to respond in a timely manner.

Another key component of our stakeholder outreach is our research collaboration with other government agencies which allow both agencies to achieve our objectives most effectively. Next slide, please.

Stakeholder outreach is more than just a project manager in research that manages a specific program. Research can make use of a spectrum of vehicles that range from the informal that you see on the left to the more legalistic formal relationships as you move right on that graphic. As shown in this slide, research has multiple tools to support this engagement and cooperation depending on the purpose of the engagement and the type of organization.

We also engage external stakeholders through computer code user groups, benchmarking, round robin evaluations, working groups in many technical areas, hosting foreign assignees, hosting and participating in Intergovernment Personnel Act assignments, as Fred just described to mention a few. We have identified good candidates for critical skill hiring from these engagements and connections. I'd also like to now cover a few illustrative examples of how our stakeholder outreach benefits the NRC, but also it brings value to our external stakeholders. Next slide, please.

Early coordination, dialogue, and preplanning are key to ensuring the NRC remains current in the rapidly evolving field of artificial intelligence or AI. AI is all around us, and in the bottom of the picture on the left, it looks like the NRC Chair has adopted a new robotic companion on one of his tours.

In the past year, more than 20 external engagements and a briefing to the ACRS on the AI Strategic Plan have facilitated a rich dialogue and led to a wide range of comments expressing diverse views. This includes engagements across the federal government, industry, academia, and international organizations. Such extensive engagement prior to issuing the AI Strategic Plan has been incredibly valuable in obtaining and assessing stakeholder views.

We have used multiple approaches to foster this outreach, including public workshops and meetings, domestic and international multi-lateral meetings, international cooperation through broad NEA and IAEA initiatives, and memorandums of understanding with both the DOE and EPRI to promote timely and targeted information sharing. This enabled us to release the draft AI Strategic Plan in July 2022 for public comment.

The nuclear industry and the public have benefitted from the transparency afforded by this early and frequent engagement, which provides them with awareness of NRC's preparation to review and evaluate the use of AI in NRC-regulated applications. The international community has benefitted from NRC's leadership to inform their own regulatory activities in this area.

My next example is nondestructive examination or NDE. Because NDE plays such a significant role for our licensees in maintaining safety, managing assets, and planning outages during long-term operation, the industry is continuously looking for new ways to increase the accuracy, reliability, and efficiency in NDE exams, while also decreasing worker exposure to radiation. The image on the right of the slide represents an NDE signal from a flaw being scanned in the picture above. This motivation has spurred the evolution of NDE techniques, training, and qualification in the nuclear industry, with the result that NDE is often an early adopter of new technologies.

NRC research has supported the adoption of new NDE technology in our regulatory role for over 40 years. Currently, the NDE community is evaluating the use of supervised and semi-supervised artificial intelligence techniques to alert a qualified practitioner of possible indications of component degradation that they can then assess. These advancements have relied upon extensive outreach and collaboration with the nuclear industry, the national laboratories, academic, international regulators, and technical support organizations, and NDE vendors and technology development companies.

Our stakeholders have benefitted by being able to leverage and directly apply the knowledge gained from our NDE research. For example, NRC just recently completed a groundbreaking evaluation on the effects of human factors on NDE reliability. This work has resulted in improvements in pre-inspection briefings and adoption of NDE inspector qualification requirements that actually reduce the number of training hours, while focusing on training activities that have a demonstrable impact on reliability. This knowledge also directly supports the regulatory reviews in the program office such as license amendment reviews and relief request reviews, and provides the regional and resident inspectors timely knowledge to better inform their regulatory duties. That is the conclusion of my remarks and now you will hear from Tom Boyce.

MR. BOYCE: Yes, good morning. I'm last, so naturally I'll be talking about the back end of the fuel cycle. (Laughter.) I'm Tom Boyce, Branch Chief for Materials and Structural Engineering in the Division of Fuel Management in NMSS. I'm happy to share with you some of the contributions that research programs provide to licensing reviews of spent fuel storage and transportation applications. Next slide, please.

Research has been a strong contributor to our regulatory activities by developing computer models that the NMSS staff uses for license applications for fresh fuel on the front end of the fuel cycle and for spent fuel at the back end.

The NMSS staff uses the SCALE code to independently assess vendor submittals for criticality, shielding, and thermal analyses. The image on the upper right shows a SCALE visualization of dose patterns within a vertical dry storage system which the staff uses in its evaluation of shielding. Similarly, the FAST code is used to assess mechanical performance of fuel rods.

In applying these tools, the staff uses its expertise together with an understanding of the physical phenomenon and the associated uncertainties to risk inform its reviews. Research uses these codes to produce studies of various aspects of applications. Examples of the reports are shown on the slide, which include assessments of how increased enrichments affect criticality analyses, decay heat analyses, and source term analyses. These codes and studies also ensure that the staff is ready for reviews of more advanced fuels, such as accident tolerant fuels. Next slide, please.

As part of the materials research for aging management, the staff is working closely with Research to assess the potential for chloride-induced stress corrosion cracking in stainless steel canisters. Stainless steels are generally quite durable, resistant to corrosion, and are expected to be in service for decades without issues. The staff has not identified CISCC at any site in the U.S. to date, and there's approximately 3,600 canisters in use. Nonetheless, the staff recognizes that CISCC is an aging mechanism that licensees should manage. Research has provided support by assessing methods of inspecting them and a robotic crawler for inspections is shown in the upper right of the slide.

The staff considered this input in developing guidance for inspections as an ASME code case. The staff included the code case in a reg guide that was incorporated by reference into the 10 CFR 50.55(a) rule, which was just issued for public comment earlier this month. The staff anticipates that industry will use this code case as part of their aging management programs.

Research is working with Sandia to develop a model for the behavior of CISCC. The elements of this model are shown on the slide. The staff anticipates that the model can inform the inspection frequency of casks in storage systems at sites that could be the most susceptible. Next slide, please.

Research activities help us be ready for new technologies. An example of this is reprocessing. The nuclear industry in a number of countries have long had an interest in reprocessing. In fact, a decade ago, the staff was developing the basis for a possible rulemaking for reprocessing. However, in response to declining industry interest, the rulemaking was discontinued in 2021. Nonetheless, the Commission directed the staff to continue to monitor interest in reprocessing, particularly for advanced reactors. To implement this direction, the NMSS staff engaged Research.

An important technology is pyroprocessing, which is shown on the slide. The technology involves separation of actinides and fission products by use of electrical current which can significantly reduce the volume of waste compared to traditional aqueous reprocessing techniques.

Also shown is the electrorefiner that is being used in a small scale demonstration of the technology at Idaho National Laboratory. Research is assessing this technology to identify potential issues such as material control and accounting, safeguards, and storage of waste materials.

As part of monitoring developments, Research conducts outreach activities such as a session on reprocessing at the RIC earlier this month. In addition, research staff conducts outreach to ARPA-E programs that are related to reprocessing, particularly the CURIE program that you heard about from the previous panel, as well as the ONWARDS program which seeks to develop breakthrough technologies to reduce the volume of advanced reactor waste, and also projects in the OPEN program such as high performance materials. Next slide, please.

Research has also been supporting NMSS in being ready for advanced reactor fuels in all areas of the fuel cycle as shown at the top of the slide. The new fuels include TRISO fuels, fuels for molten-salt reactors, and metal fuels. Most of these fuels are new and are enriched as high-assay low-enriched uranium.

For the back end of the fuel cycle in particular, we are building on the same computer codes that are used for analyses of reactor accidents such as the MELCOR severe accident code and SCALE.

For example, in February of this year, Research conducted a public workshop on SCALE and MELCOR for a high-temperature gas-cooled reactor which was attended by about 100 participants from NRC, DOE, industry, and international organizations. Workshops on other technologies are planned in the future.

Research conducts technical assessments of various issues for advanced fuels. I'd like to point out that these assessments build on the recommendations from a series of reports by the Center for Nuclear Waste Regulatory Analysis which you heard from in the previous panel that identified potential information needs for advanced reactor fuels.

As Louise discussed previously, we are actively engaged in many domestic and international research programs as we monitor developments by the industry. A notable activity is the Studsvik Cladding Integrity Project where participating countries share information on back end storage of spent fuel. This concludes my presentation. I'll now turn it over to Cathy.

MS. HANEY: So, thanks very much, Tom. I want to thank our staff who continue to demonstrate NRC's commitment to supporting regulatory readiness through agency research activities. Their dedication, energy to innovate, and technical results provide the agency with essential tools to aid efforts to accomplish our safety and security mission.

In addition to Ray, I'd also like to thank Louise for all of her support in the area of research, as well as across the board. I've known Louise for many years and I wish her very well in her retirement. So, we've now completed our presentation and look forward to answering your questions.

CHAIR HANSON: Thanks, Cathy. Thanks to all of you for your presentations. I mean, having been in other places in the government, I've really been long impressed with the Office of Research and the amount of high impact activities with relatively modest funding amounts, so thank you all.

And I think we had some really good examples today of that in the presentations themselves and I want to get to a couple of those, particularly Mike, I'm going to put you on the hot seat in a minute.

But first, one of the things that caught my attention, Tom, was this chloride-induced stress corrosion cracking issue, and because I do think that we need to, in order to have a really kind of high impact and effective research program, there is a certain element, I think, of having to kind of risk inform our research priorities and our activities.

And then we kind of get to chloride-induced stress corrosion cracking, which is a phenomenon, but not one that's actually been observed in the United States. And we've got 3,600 casks, and a growing proportion of those have actually been on pads for decades and we haven't seen them.

And so, I had a couple of questions like how much research is enough in this area, and are we done, and if it's a phenomenon that hasn't been observed, even if it exists, at what level should we be requiring licensees to actually manage that? And so, I guess, maybe you can start anywhere in there you like, Tom.

MR. BOYCE: Well, the reason we got here, I think, is because we were convinced that it had the potential to manifest itself.

CHAIR HANSON: Okay.

MR. BOYCE: Like in marine applications, stainless steels are used, and we're seeing a fair amount of chloride-induced stress corrosion cracking because you're immersed in seawater and there's a lot of chlorides there.

You heard from the Center. They did some studies that looked at various factors that made specifically austenitic stainless steels that are primarily used for our casks be susceptible to CISCC, and on David's slides, he showed the onset of pitting for chloride-induced stress corrosion cracking.

And so, of course, those were lab conditions, and they were accelerated, I can say, or exaggerated compared to what we'd see, but it convinced us that it had the potential to manifest itself.

So, that work was done a while back and it was probably, of all of the various aging mechanisms, the one that was deemed credible to potentially manifest itself. So, we put it into our MAPS report, which is our technical basis document for license renewals, and so we're requiring inspections of sites right now and that's uniform.

So, going after the risk-informed aspect a bit, we're trying to collect data over time that we're seeing from these inspections to see what is the likelihood of onset. Based on that kind of data, we might be able to adjust the frequency of inspections depending on whether the conditions exist at a given site. On my slide, I showed a picture of an ISFSI right next to an ocean.

CHAIR HANSON: Yeah.

MR. BOYCE: You know, I did that for a little bit of dramatic effect. In all likelihood, that site would probably have a given baseline level of inspections, but those that would be more inland and away from sources of salts might be able to be reduced in inspection frequency.

So, the other thing you can do is measure in lab conditions the length of time it takes to get from pitting into actually crack initiation, and that's shown as one of the phases in the model, and so depending on the length of time, that might also risk inform the degree of the timing or frequency of inspections that we do.

And finally, how long does it take for a crack to actually grow if it initiates? And so, if it takes three decades to grow, that gives time to monitor and assess. And finally, if the crack does, in fact, propagate significantly, you also have time to repair. So, at each of those stages, you have the potential to adjust the frequency of inspections based on the risk that's shown from the data.

CHAIR HANSON: Thank you. I think that kind of -- those qualifications and that kind of hypothesis-driven approach is important context around this issue. I mean, we -- there is a balancing act there, right, because we are seeing ISFSIs that are being licensed out to 40 years. They may be licensed out longer. We've had other kinds of analyses about the lengths of these things, and yet, you know, you used the word potential a lot, and that line between potential and actual and observed is an important one as well, right, in terms of the empirical phenomenon for this, so thank you.

Mike, I wanted to ask you a little bit about the seismic analysis for the NuScale emergency planning zone methodology, and in your view, kind of what were the issues that may have been particularly challenging in the review, the technical issues? And based on your experience, kind of what should future applicants consider in their applications in order to help the staff make kind of risk-informed safety decisions around EPZs for SMRs and other technologies?

MR. FRANOVICH: Thank you for that question. Actually, it was a little bit of a journey in treatment of external events for EPZ issues, and one of the challenges is when you deal with a community that's vested in designing a reactor, you look at it from that prism. An EP is a different area in terms of a layer, independent layer of defense in depth. So, the engineering community tends to look at can I use probabilistic methods? Do I use cutoff frequencies? How rare an earthquake? Do I have to address that when there are impacts also to civilian infrastructure?

And it requires a little bit of a paradigm shift for people to recognize that emergency preparedness will be there, plans will be there, but do you need preplanned actions? What amount of this residual risk that's left over after we do the safety review should be captured by an EPZ, if it's needed? And that dialogue in searching for how to treat rare seismic events took a long time. I would say the applicants struggled looking for information from other precedent type of work.

Eventually what we landed on is let's look at our Fukushima work. We were looking at trying to do best estimate analysis about the capabilities of these facilities. They had margins in them and so did the SMRs. One of the difference about SMRs is they don't have all of the layers of extra margins that were added in the current operating fleet from all of these other hazards, so residual risk there tends to be somewhat controlled by seismic risk.

So, what portion do we want to really capture? Not everything. We don't want to have to deal with extreme things that are just out on the tails of analysis, so there is some subset we need to look at, and if there's multi-modules involved, what are the cliff edge effects? Because an earthquake in particular can affect more than one unit.

And so, coming to a process, it's all about process in dealing with uncertainties, that was the key discussion that we had with NuScale, is that we need to have a process to deal with these uncertainties, and look at a range of earthquakes and land on, depending on where that particular unit is situated, is there a lot of margin on that site? Is it a low seismic area or is it a high seismic area? What do you need to do in looking at the timing events and all of those other factors about whether or not you need these preplanned actions?

So, I think for the rest of the community, the other vendors who are getting into this business, the key issue is you need to change your mindset a little bit when you're dealing with EP and EPZ. It is not just the typical things you deal with in the safety case, and that there are margins and we are looking for best estimate, realistic type of work there.

I would also say in the advanced reactor area, there has been some breakthrough work to allow for more realism in terms of do you use design codes for the performance of the units or are you looking at things like what we've seen in some societies like ASCE and retrofitting of buildings? Well, we're not so much interested in whether or not the structure is going to be usable, but will it survive? Asset protection is for the utility. We're interested in public health and safety.

So, more relaxed standards that would allow for deformation and things like that, these are the things, the conversations we're having. So, I think between the advanced reactor work and what we did in the EPZ area, I think it's all about dialogue.

Because I find quite often when you're working with different vendors, you're almost repeating the same message you had with the previous vendor, and it's like well, we need to have some more group discussions about these insights, and that way we're being more efficienct, just efficiency is really what's -- it's a killer when you have to repeat the same story over and over for vendor after vendor.

CHAIR HANSON: Thanks very much, Mike. That's really helpful. Commissioner Baran?

COMMISSIONER BARAN: Well, thank you for your presentations and all of you work. Tom, you talked a bit about NRC's research-related or reprocessing spent nuclear fuel. Can you tell us a bit more about what Research is looking at in that area and the time frames for that work?

MR. BOYCE: Yes, there's a number of issues, excuse me. In general terms, we're taking a look at any potential issues that we might find from looking at the latest technique for pyroprocessing which I mentioned, any safety analysis methodologies that may be applicable, and any acceptance criteria. That's generally.

Specific technical issues would be criticality and also radionuclide inventory. We don't have huge experience in that, but we need to be able to have some codes that make sure we address those particular issues. They're important for accident progression. The SCALE and MELCOR codes would be the ones that we would apply there.

Material control and accounting is something that would be of interested. You heard about the ONWARDS program, and what they're trying to do is measure the products that come out of the pyroprocessing to less than one percent. And so, what that does is also help you with material control and accounting, but perhaps more importantly, it also minimizes the fissile material that's in the waste streams. There was a goal stated, I think, from the previous panel to try and totally eliminate that, which is wonderful, because it would certainly make MC&A a little bit easier for us, but would benefit larger society.

The pyroprocessing technique involves high temperatures and also highly radioactive environments, so we would like to learn a little bit more about what measures need to be put in place for those types of things.

And finally, the radioactive forms, like let's assume that the goal is not achieved that all of the fissile material is eliminated. What are the waste forms that that would need to be put in, and how would it be transported in various transport packages and stored for a particular period of time? So, we'd be doing research into those type of technical areas.

I would say the good news -- let's see, the time frame. Our time frames are driven primarily by our anticipated licensing applications. Those schedules are actually proprietary, but in general terms, over the next several years.

So, we benefitted that we're not starting from scratch. Even though pyroprocessing sounds new, it's actually been around for a while. Argonne National Lab has had a pilot facility going for over 40 years, and I think Dr. Shafer said she was heading out to Argonne for another meeting. There's also a functioning facility at Idaho National Lab which is actually doing it, so we have effectively prototypes that we can learn from, which is fantastic.

We can update our SCALE and MELCOR models using some of the information we're already getting from other advanced reactors' efforts. I did mention some of the workshops that Research is doing. Even though that tends to be focused on the reactor side, validation of those codes translate very well to the back end. In particular, the molten-salt type of technology that would be used as part of pyroprocessing actually, we can probably have SCALE and MELCOR translate from the work that we're doing for molten-salt reactors to that.

So, the last piece that fits together fairly nicely is the efforts that ARPA-E is doing for ONWARDS which is focused on the measurement of those, the actinides and waste forms, and also the work that Dr. Shafer is doing for CURIE which is focused on a variety of techniques to enhance pyroprocessing and the process itself.

We do meet periodically with the heads of those programs. We met with Dr. Shafer as a team, the multi-office team a couple of months ago. Bob LeDoux interviewed me when he was getting ready to try and figure out where he wanted to take the program. I was one of many, so I'm sure I gave him brilliant insights, but at any rate, he's done great, much better things. So, and we intend to maintain that type of communication and data sharing. As was mentioned, they are three-year programs, so we don't have hard data to show right now. So, I think it's actually, in spite of the fact that we have a new technology, we have a fairly good base to evaluate it with.

COMMISSIONER BARAN: All right, thanks, Tom. That's helpful. Mike, recently the staff issued a second information notice on risk insights from high-energy arc faults that discussed operating experience, testing, and analysis. This was a multi-year effort. Can you discuss some of the results from that research?

MR. FRANOVICH: Certainly. It has taken a few years to get to a point where we can do an appropriate technical assessment. Some of the insights were that actually risks can increase for certain types of HEAF events, in particular from bus ducts. When we learned from the testing and the operating experience that the zone of influence, this is the impact zone from the actual arc in terms of affecting a target like a cable or some other equipment in a compartment, those actually can be larger.

On the other hand, we have also learned that for switch gear, that the zone of influence that we're using from the older methods, actually there wasn't much shift. So, the challenge we typically see in these kind of hazards is they are very plant-specific and that's because of the configuration and layout of the facility, so we did do assessment at two facilities working with two utilities. We were able to do different configurations to get some insights to say yes, there can be some significant scenarios, but on balance, when you look at that and some of the other experiences we wanted to share, that these can be complicated events to manage during an actual HEAF event. They range from sometimes they self-extinguish to they propagate to be a little bit more complex events for operators.

So, between the qualitative insights and the risk insights, we landed on essentially no new requirements. On the other hand, there's a lot of good information there, and if folks are actually wanting to upgrade and update their models, these new methods that we have available from this body of work, which was done collaboratively with EPRI actually, I must note that as well. And one key thing from EPRI that we've gained actually working with them is the importance of a concept called fault clearing times. So, how long does the fault actually stay in, two seconds, four seconds? That has a direct proportion to the size of the arc, so that's an important insight for electrical engineers when they're doing their breaker relay coordination work, and preventive maintenance. Preventive maintenance, prevention goes a long way in terms of risk management, so we wanted to convey all of that information to our stakeholders.

COMMISSIONER BARAN: I appreciate that the staff did that work. Let me ask -- thanks for talking a bit about SPAR-DASH. The SPAR models, I agree with you, are so important for NRC's independent oversight role, and SPAR-DASH is a great way to leverage those models to gain risk insights for our licensing and oversight work. Last year, the staff mentioned that it was exploring increasing the number of planned SPAR model updates performed each year. How is that effort going?

MR. FRANOVICH: We had a slight impact from COVID, I would say, but we're recovering from that effort. We are trying to do more benchmarking and we've done some exchange of staff with Research actually and through an agreement with Idaho National Lab to do further benchmarking of the models.

The licensees are changing their models, so we need to take a look at that and see how that compares against our standardized platforms, so we've actually boosted our effort to try to do more of that work so that we're keeping pace with the activities in the industry.

COMMISSIONER BARAN: Okay, great. Ray, could I ask, I would just be interested in an update on the status of the Level 3 PRA project. Where are we on that?

MR. FURSTENAU: Yeah, on the Level 3 PRA, it should be concluding. It's winding down, but it's been winding down for a while, but it's -- because we put limited resources on it because they get pulled to other things, but it is wrapping up and probably finish it around the end of '24 or early '25, very -- I think it's less than $100,000 left in contract costs. Most of it is getting reports out for public review, and receiving comments, and wrapping up on a summary of that. So, the end is near, I'd say.

COMMISSIONER BARAN: And, you know, it has been a while, this effort. I mean, can you talk just a little bit? And we have like about 45 seconds left. I mean, do you think it's going to end up being a significant thing when it's done? Is it going to have been worthwhile and how do you see it in terms of the outcome?

MR. FURSTENAU: Yeah, I think, you know, it's a large project, almost, you know, gosh, how would we ever want to do this for every single plant? But I think exercising that on a multi-plant site provides risk insights to maybe what is important to safety in the event sequences, for example, and the resulting consequences. So, it's not that you necessarily want to go out and do that for every existing plant. It's the insights from going through that methodology and process.

COMMISSIONER BARAN: Okay, all right, thank you.

CHAIR HANSON: Thank you. Commissioner Wright?

COMMISSIONER WRIGHT: Thank you, Chair. Good morning, and thank each of you for your presentations and for the time it took you to get it together, too, because I know planning for these meetings, especially right on top of the RIC, oh, my gosh, so thank you. It has not gone unnoticed and appreciated.

So, Ray, I mean, you did use an Einstein quote, but I like your quote. If you don't participate, you can't influence. I like that and I'll always remember that, and I'll use it, so thank you. So, I really appreciate the work that you and your team do, and also, again congratulations on the RIC. You did a great job there along with Andrea who is sitting over here.

So, I wanted to follow up on something that you discussed and we touched on during the first panel, and that's the future work force. And with Louise Lund's upcoming retirement, that's just one more example as to why it's important, right?

And so, and by the way, Louise, I wish you much happiness and good health in your future years, and I hope they are many, so congratulations.

So, Ray, during your presentation, you mentioned that increasing the visibility of the future-focused research activities to universities, and I wanted to ask you, maybe combine a couple of questions, right? And shed a little bit more about what are some ways you plan to do that, and then how do you go about aligning the future-focused research activities with the needs of the university and the industry pipelines?

MR. FURSTENAU: That's a great question. That's really the ultimate goal, I think, is integrating those two and we're certainly not there yet, but I see that both the university mission-related R&D, for example, what's coming out of those or what will come out of those should really feed the ideas to the staff as well, that says okay, maybe I've got an idea for a future-focused research project that kind of takes it a little bit more towards what I want to do as an NRC staffer, and then also getting the results of our future-focused research more publicized, more out there to the universities to help feed into hey, that gave me an idea of what may be more blue sky research I might do and propose under the mission-related R&D.

But I think what I'd like to see is just that awareness of what each other are doing, and I think part of doing what we've done is the seminars, that we have some of the mission-related R&D grants come in and give seminars to our staff to let them know what they're doing, and I think we need to reciprocate, too.

We do seminars on our mission, on our future-focused research, but they're not always a wide cast, and so I think we can do better in that area as well. So, I think just say we can do better and have those programs be complementary of each other and help the agency.

COMMISSIONER WRIGHT: Well, I know one thing that you and I have talked about over time and that I've noticed is that you don't sit still. You're always trying to get better and do things better, and I appreciate that.

Mike, I'm going to come to you for a second here. At our last Commission briefing, we discussed the SPAR-DASH, right, application, and at the time, and I know you kind of talked about it a hair just a minute ago, at the time, external stakeholders had expressed uncertainty about, you know, how the agency uses risk information in making decisions.

So, I'm interested a little bit more, maybe a little more meat on how the communication has been with the external stakeholders regarding the use of, you know, risks to inform decision making with these rules and what kind of feedback have you gotten? I know you talked about staff, but I'm more interested in, you know, maybe the industry conversations.

MR. FRANOVICH: So, it all depends on which group and industry you're speaking to, and the industry is, as you know, not a monolith. There are different sectors. In the operating reactor side, which we deal with primarily, we have a very strong relationship with the PWR and BWR Owners' Groups, as well as with EPRI and other groups, and we have frequent exchange. We meet every four months. We talk about what's on our agenda, what's on their agenda, and so they understand that our goal in some of these evaluations, for example, in these emergent issues, that we're trying to use best estimate, and they have been very proactive to be supportive if we need information.

So, and the general feedback has been they have good confidence in our results. In fact, we got very positive feedback of how our issue with HEAF has actually turned out. So, it depends on which group you're working with. I can't speak to all groups because risk is ubiquitous -- and it's a very popular topic. It's used in lots of different parts of the agency, but in this particular community, I would say we get very good feedback.

COMMISSIONER WRIGHT: Thank you so much. Fred, how are you? So as one of the two staff members that are -- you know, as you mentioned, you are participating in this Advanced Construction Technology Initiative, right?

MR. SOCK: Yes.

COMMISSIONER WRIGHT: Can you share a bit -- a little bit more about any early lessons learned or insights to whether the inspection and acceptance criteria the staff are currently using will be -- will they need updating? Maybe what kind of updates that might be? Will they be moderate or substantial?

MR. SOCK: Yeah. Most of the -- we had to -- that are being designed now, deeply embedded structures. And the current inspection manuals and procedures are not tailored towards this type of structures. So definitely the inspection procedures and manuals will have to be revised.

And that's something that I think it is ongoing with the ACROP, the Advanced Construction and Oversight -- Reactor Oversight Program. They will have to revise it to be able to monitor the structure that is embedded. First, monitor the area before the excavation starts, to monitor the area around the reactor building when construction is going on. And they can use that data to kind of inform the analysis as to the -- I'm talking about the ACT construction. They will be able to use the data to be able to inform the analysis for the reactor -- reaction of the soil around the structure.

COMMISSIONER WRIGHT: Do you think that these will be real -- a hard lift, an easy lift, a moderate lift?

MR. SOCK: The way the program is going, I see it as a big lab that we obtain all types of -- of experiences.

COMMISSIONER WRIGHT: Okay.

MR. SOCK: And at the end it will put out a paper that gives the pros and cons of the exercise. And so far it has been going well, which it's just a matter of deciding exactly whether we want to go to a half-scale diameter of a structure or full-scale diameter. But, yeah, it has been -- it has been good to date. Yeah.

COMMISSIONER WRIGHT: Okay. All right. Good. I'm going to stay with you and -- but, Louise, I've got to give you the last bite at the apple here, because this may be one of the -- you know, this may be your last time before us, too. So I'm interested if you all think there are other areas we should be collaborating with DOE, or maybe another entity, to improve NRC's technical readiness for advanced nuclear reactor applications.

MS. LUND: Well, actually, we have been -- before Fred went to the project that he working in, we actually had -- during the pandemic we had one of our staff in Division of Engineering go down to Oak Ridge to get involved in a project in -- with the Transformational Challenge Reactor and look at, you know, in the Advanced Materials, AMT, we have an AMT action plan. But two areas that we were very interested in, one was the impact of AMT, Advanced Manufacturing on microstructure, and also non-destructive examination. And going down, having boots on the ground, having somebody that is actually able to talk to the people that are putting together, you know, the actual components, watching it in real time, you know, is just such a benefit to the agency, because the question you ask about, is our guidance sufficient, do we need more, do we have gaps, you know, that is where we want to get insights, you know, in that and be able to have some meaningful dialogue with the program office as to, when they start seeing applications come in, are we poised with everything that we need.

MR. SOCK: If I may add, we have to find a way to have the licensee or the applicant be comfortable when they have an NRC person within their midst. It took about two to three months for the NRIC team to be comfortable with me, because -- with the GEH team, because they were not sure whether I was an NRC employee listening to what they are doing or -- so I found a way to ease their hesitation and just told them I'm an INL employee, just happen to be an NRC staff member. And after a while they become comfortable and just basically talked about how the sausage is made.

COMMISSIONER WRIGHT: Right.

MS. LUND: But the answer to your question is, yes, we should consider that, you know, for selected pump areas where it would be beneficial.

COMMISSIONER WRIGHT: Right. Thank you. And, Fred, I've been there with people -- trying to figure out if people knew who I was. Thank you.

CHAIR HANSON: Thank you. Commissioner Caputo?

COMMISSIONER CAPUTO: Thank you all for being here today and preparing for this meeting. I especially want to say a special thank you to Fred. It's nice to sit across the table from you. I very much appreciated working together during your collaboration with INL when we crossed paths, and I am thrilled to see you bring that experience back here and inform the work that we do.

As I mentioned earlier, I'm going to focus again on how we balance the research that we do and the choices that we make between backward-looking or confirmatory research and future-focused research, particularly given the challenges that we see coming with advanced reactor technologies. And particularly out of respect for the taxpayers, licensees, and applicants that fund us, we need to tightly manage our research resources to focus on matters that are safety-significant and focus on effective outcomes that we need to make safety findings and prioritize the work that we do based on a clear accounting of safety significance.

So like the Chairman, the chloride-induced stress corrosion cracking that he asked about earlier also caught my attention. And I know Tom talked about the chloride-induced part of it. I'm going to focus on the stress corrosion cracking part of it or particularly the stress part of it, because I find myself questioning where the stresses ultimately come from and how significant they are.

You mentioned a marine environment. You know, what we see with canisters, there is not a lot of structural loading like you'd see with a ship hull. There is not a lot of cyclical loading like you'd see with moving parts. You don't see huge thermal stresses like you'd see in an emergency core cooling system. We are dealing with natural convection, which has some cyclical thermal, but not that significant.

So my question, you know, for Ray and perhaps Tom, in making the decision to head down this road, you know, what -- what level of risk information was used, and what kind of a cost-benefit analysis was done? Because we -- basically, we are pursuing some research, but actually we've gotten to the point of requiring inspections. And I'm wondering, how did we get here in terms of using risk information and deciding that this was a cost beneficial use of both our time and licensees'?

MR. BOYCE: I'll try and start, pardon me, and then Ray will probably bail me out. So I did talk about the Center doing the work and establishing the conditions for susceptibility. And so I think that work was probably done a decade ago, and we are trying to add to our base of knowledge. But to answer your question about where do the stresses come from, they are primarily welding and the weld residual stresses, and that is where you'll end up getting the CISCC primarily. So --

COMMISSIONER CAPUTO: If it's observed, which it hasn't been yet.

MR. BOYCE: If it's observed. Correct. Correct.

COMMISSIONER CAPUTO: So my question is, how -- how, given that this has now spanned 10 years, how has risk information been used in terms of deciding what the safety significance of this phenomena might be in the future?

MR. BOYCE: Well, it's important to recognize when we say "inspections," these are licensee inspections. It doesn't change the burden.

But you're also doing a sampling. You're not inspecting the entire fleet of casks that are on your ISFSI pad. You're only inspecting a select few that might be the most susceptible, like the ones that are closest to the ocean.

So the level of burden isn't great. That data is being fed into an INPO database called the Aging Management Information Database, AMID database. And so if there are no chloride-induced stress corrosion cracking issues observed over time, as I had stated before, we would expect to roll back our inspection frequency using risk-informed thinking.

COMMISSIONER CAPUTO: So how long are we going to wait before we risk-inform what we're doing?

MR. BOYCE: That's a great question. I would -- I would probably try statistics first to make sure we're statistically significant. If that doesn't work --

COMMISSIONER CAPUTO: Well, so far we're statistically significant at zero, because it hasn't been observed.

MR. BOYCE: Correct. We would have to -- I'd have to go back and take a look at the length of time we anticipate for the onset of pitting before I could probably answer your question about length of time.

COMMISSIONER CAPUTO: Shouldn't we answer that question before we have licensees looking for something that may not manifest for years?

MR. BOYCE: I want to say that question was answered before we got into aging management, but I don't know the answer today.

COMMISSIONER CAPUTO: Okay. So I'm going to shift a little bit, you know, to Ray and Mike. You know, NRR has a process, very low safety significance resolution, to basically examine and conclude whether or not low safety significance items actually require further regulatory attention. Does the Research Office have that kind of a process for dispositioning items that are not necessarily safety significant and don't warrant further review?

MR. FURSTENAU: We don't have a process per se. I do, you know, want to try to answer your question on how we look at risk and significance. You know, research, especially in the regulatory environment, I think is really about uncertainty and sensitivity. And you -- you want to try to reduce uncertainty and to allow for understanding whether you are within the margins are outside of the margins. You could have more margin than you thought or it could be the other way around.

But I think sensitivity is -- is as important as a component, doesn't matter. You know, that's the way I look is -- okay. So what? If you -- if you have a large uncertainty, but it has nothing or little to do with the safety significance or risk, then we ought to not be spending any more time on it. And that's I think --

COMMISSIONER CAPUTO: So what process do you use to make that decision?

MR. FURSTENAU: Well, I know we don't have a process, Commissioner. It's that it's really reliant on the expertise of our -- of our staff and what we know about -- about the uncertainties to help make those recommendations and judgments on whether we should be worrying about it or not.

MR. FRANOVICH: If I may add, I think -- there is no formal process, but if you were to look at the user need process when we actually write user need requests, I would say over the last few years there has been increased intention -- attention to whether or not is this potentially risk significant? Do you have the means to actually do that assessment? What are we getting in return? And so those user need requests have gone through lots of scrutiny back and forth between the two offices to make sure that this is really a wise use of resources.

Another example I'll give where it is not a formal process -- it is a formal process, but how risk is used most recently -- there was a pre -- potential pre-generic issue that came in on treatment of diesel generators and its protective features. It's a long story, but the bottom line was that risk assessments were done actually, and working with NRR to determine that, really, this was not an issue that was of significance to actually do any more additional work.

So the work was concluded appropriately and shut down, so it really happens on a -- I guess more of a program-by-program basis and more through the user need request if it's something larger.

COMMISSIONER CAPUTO: I'm glad you mentioned the user need request process, because one of the things that I struggle with is the fact that a user need is put before research to answer a question that is necessary to make a licensing decision.

The challenge comes when that decision is made and that licensing need is over, and yet the research that was triggered by that question can continue years after the regulatory decision has been made. And that becomes one of those situations where I think there really needs to be scrutiny about whether those resources are necessary.

If the resources were necessary and the resource was necessary to make a decision, we have made that decision and moved on. Then I think there's room to question whether continuing resources really need to be spent. There will always be confirmatory research that we need to continue and monitor. Aging is a clear example of that.

But I think I certainly have questions about just the sheer magnitude of user needs requests that have continued long after regulatory decisions. So I think it would be important and useful for the Office of Research to develop a process similar to NRR's VLSSIR process for dispositioning research that is either outdated, low safety significance, or overtaken by events long after the decision has been made, particularly in light of the significant budget increase that NRR -- that Office of Research is asking for going forward. If more money is needed for research, I think we need to begin by scrutinizing where it's being spent that may or may not necessarily be safety significant at this point in time. Thank you very much.

CHAIR HANSON: Thank you. Commissioner Crowell?

COMMISSIONER CROWELL: Thank you, Mr. Chair. Good afternoon, everyone. I realize I'm standing between the end of this meeting and lunch for everyone. So, Cathy, I wanted to spend some time talking about human capital programs, if that's all right? I'm just kidding.

(Laughter.) But I am -- I do want to actually pick up a little bit on what Commissioner Caputo was hitting on. And, Ray, I don't know if this is going to go to you or Tom or whoever else wants to fill in the gaps.

But, you know, as we think about the value of our research and the risk significance and the probability of these things happening in that context, how are we factoring in impacts from climate change? So like inundation, some increased highs and low temperatures, rapid swings in high and low temperatures, drought, coastal erosion, like anything that could impact a licensee's operations. You know, how do we factor that into the probability and the research effort?

MR. BOYCE: Well, I'll do my best again. We've got pretty wide parameters right now on the things like temperature. I'll use that as an example. The systems are designed to handle down to something like minus 40 degrees Fahrenheit and positive 138 degrees Fahrenheit. That bounds most of the sites quite substantially.

So just from the -- just from the static condition of storage, we appear to be -- we have more than adequate margin apparently. From the standpoint of, say, sea level rise -- and, again, I'll use the picture that I had, which was from SONGS -- we have made sure that for natural hazards that could increase, we have adequate protection so that the hazards would not impact the ISFSI. So I would say that we would not be spending our resources on research for that at the moment. Ray?

MR. FURSTENAU: Yeah. I'd like to just add an example of -- there's a future focused research project on extreme conditions, because

I think, you know, besides climate change with advanced reactor concepts that may be locating in regions that we would have never thought of locating a plant before, how does that matter with -- for let's say Alaska, for -- for example, and weather -- those extreme weather conditions and what -- what should we be concerned about that maybe we -- we haven't been concerned about as much before. So I think we have been and need to continue looking at extreme conditions, you know, which can, you know, be affected by climate change as well.

COMMISSIONER CROWELL: Yeah. And, you know, and drought and water supplies. And maybe in Arctic areas it's basically just a cold drought. And, Tom, I actually think what you ended on is -- it's not that we're not considering those things. I think it's that you already are by the fact that you are bounding so widely that you are capturing a lot of those extremes, and I think that is important to know.

Tom, I'll stick with you for a second. So the inspection frequency in the Sandia model that you were talking about, you know, you had the picture of the coastal area which, you know, may, you know, be an example of lending itself to more frequent inspection. Can you give some examples of where -- other geographies that may require either more or less frequent inspections based on the model?

MR. BOYCE: I don't -- I don't know if I mentioned the frequency, but generally we're at five years as our baseline. Sorry. I think I'm getting a cold here. Apologize to Louise. But I -- I would say we would be looking to decrease the frequency rather than increase the frequency.

That should be plenty of time to -- given what we perceive as the timeline, plenty of time to detect and identify the issues. So other locations that would be susceptible potentially is anything that has precipitation with salts. If you've got your ISFSI located at a reactor site near the cooling towers, that's a potential type of issue. So I think the salt environment, the oceans, and near cooling towers are the ones that are most easily identifiable. There may be other site conditions where external facilities would put salt into the air, but I think that would be a one-off, if it happened.

COMMISSIONER CROWELL: Okay. Thanks. Last question, and, Louise, just because we haven't met and you're a short-timer, and Tom is going to get you sick, so I hope you have some sick days left in there before April. (Laughter.) So the -- I'm not AI scares me. I don't know a whole lot about it, but I'm curious to know on the strategic plan, you know, it's still out for public comment as to -- is it still open for public comment?

MS. LUND: Yes. Actually, they have been resolving a lot of the comments, and they will be putting out, you know, a final version, you know. I think that they also plan to, you know, have it be more a living document going forward, but really the final -- that will be coming out.

COMMISSIONER CROWELL: If it's appropriate, could you give any flavor of what kind of comments you've been getting? Themes or otherwise?

MS. LUND: Well, I don't have all of the information on that, but I think that a lot of it has to do with wanting to understand what we're looking for as far as criteria for validation and, you know, all of these things that were discussed before, especially Dr. Shafer when she is talking about trustworthiness and the validation and really what that would involve, you know, for us.

You know, and I think, too, what's interesting about AI/ML is it so permeates our life, and it permeates the life of the industry, too. I think about, you know, she was talking about the -- Dr. Shafer was talking about the car. I think about, you know, a furnace filter that has, you know, a really smart sensor that can tell you when it needs to be changed. You know, and as we go forward and the supply chain really incorporates more and more of that, you know, I -- I think that that's what I think is helpful about right now us really trying to figure out what we really need to focus on as a regulator. And that's really, I think, what the folks that we have engaged with really want to understand about this, what we would need to see and what criteria we would use, and you know, as they go forward, and implement that in regulated activities.

COMMISSIONER CROWELL: Now I'll throw you a curveball, which may also expose my naivete on AI. But I heard on the news yesterday that 40 tech leaders, including Elon Musk and others, have called for a slowdown on AI. Does that impact in any way your or the NRC's efforts on AI?

MS. LUND: Well, I think that as we try to understand how it's being used, whether it goes slow or fast, I think it's incumbent on us, as with any technology that is different than what we had been used to in the past, for us to understand, really, how it is intended to be used and whether there is safety implications of that, because of course it's incumbent on us to assure, you know, that we understand reasonable assurance, you know, of adequate protection for, you know, any facilities that we oversee.

So, you know, I think AI is out there. It's being used. Machine learning -- in fact, I think, you know, one of the things I mentioned, in non-destructive examination, you know, they have been evolving for quite a while into using machine learning techniques and being able to understand, you know, how to get the system to do more things in an automated fashion.

And part of it is, you know, you were talking about, you know, having critical skill sets. You know, in the non-destructive examination area, that is one of those areas both -- you know, in industry where, you know, there -- I think it's challenging finding people that are, you know, skilled in all of these areas. So the question is where can you automate something?

COMMISSIONER CROWELL: Yeah. I think AI is -- a big part of it is being -- responsibly using it. But in terms of what it could provide in terms of insights for what we all do here at the NRC, it could be hugely valuable. So I wish you the best, and that's all I have. Thank you, Mr. Chair.

CHAIR HANSON: Thank you, Commissioner Crowell. So many places to go with the AI discussion. That's for sure.

But, you know, now I am between lunch and everyone, so let me close with a couple of things. Let me join Cathy and Ray and a number of others in congratulating you, Louise, on your retirement. Thank you for your service. It is deeply appreciated. So enjoy.

And, also, since this is the first Commission meeting back since the RIC, let me join Commissioner Wright in just congratulating everyone on the -- on a very, very successful RIC. It really came off I think incredibly well in a hybrid environment. I know we had been sweating this for a while, about whether or not we could do a fully hybrid RIC, and we did it. And I think the bar has been set really high going forward. I got a lot of really, really good feedback from all kinds of people at side events and walking the halls and other places. And so, again, I know there are -- Research was one of the main co-sponsors of this, along with NRR. You know, Andrea and Ray, our very own Regis and Kathie Lee, did a great job up there on the stage. And I know there were lots of other organizations throughout the agency, you know, Admin and CIO and a bunch of others. And I hope we get the opportunity to celebrate appropriately when the time comes. But, again, congratulations to the staff on that. Really appreciate it. And with that, we're adjourned.

(Whereupon, the above-entitled matter went off the record at 12:27 p.m.)