UNITED STATES

NUCLEAR REGULATORY COMMISSION

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BRIEFING ON ADVANCED REACTOR PREPAREDNESS THROUGH

REGULATORY ENGAGEMENT AND RESEARCH COOPERATION

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TUESDAY,

APRIL 13, 2021

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The Commission met via Video Teleconference, at 9:00 a.m. EDT, Christopher T. Hanson, Chairman, presiding.

COMMISSION MEMBERS:

CHRISTOPHER T. HANSON, Chairman

JEFF BARAN, Commissioner

ANNIE CAPUTO, Commissioner

DAVID A. WRIGHT, Commissioner

ALSO PRESENT:

ANNETTE VIETTI-COOK, Secretary of the Commission

MARIAN ZOBLER, General Counsel

EXTERNAL STAKEHOLDER PANEL:

ASHELY FINAN, Director, National Reactor Innovation Center, Idaho National Laboratory

J. CLAY SELL, Chief Executive Officer, X-energy

SIMON IRISH, Chief Executive Officer, Terrestrial Energy USA, Inc.

STEPHEN KUCZYNSKI, Chairman, President, and Chief Executive Officer, Southern Nuclear Operating Company

TODD ALLEN, Senior Visiting Fellow, Third Way

STEVEN SWILLEY, Deputy Chief Nuclear Officer and Senior Director, Research and Development Nuclear, Electric Power Research Institute

ED LYMAN, Director Nuclear Power Safety, Union of Concerned Scientists

NRC STAFF:

MARGIE DOANE, Executive Director for Operations

ROBERT TAYLOR, Deputy Office Director for New Reactors, NRR

RAY FURSTENAU, Director, Office of Nuclear Regulatory Research (RES)

RAJ IYENGAR, Chief, Component Integrity Branch, RES

MARILYN DIAZ MALDONADO, Chemical Engineer, Office of Nuclear Materials Safety and Safeguards

MICHELLE HAYES, Chief, Advanced Reactor Technical Branch, NRR

P R O C E E D I N G S

9:01 a.m.

CHAIRMAN HANSON: Good morning, everyone, I convene the Commission's public meeting on the NRC's preparedness activities for advanced reactors through regulatory engagement and research partnership.

The topic is very timely as the agency's focus on advanced reactor preparedness continues to increase with ongoing stakeholder interactions.

It's also very important to keep the public informed of developments in this area of high interest so I thank you all for supporting this meeting today and I'm look forward to a very good conversation.

We'll hear from two outstanding panels this morning. First to present are participants in our external panel, following that we'll have a short break and then we'll hear from the NRC staff.

So, before we start, I will ask my colleagues if they have any remarks to make? Okay, so with that, we'll begin our external panel.

Each panelist will have six minutes to present and I intend to proceed in the order in which you all are listed on the public notice for this meeting.

We'll begin with Dr. Ashley Finan, who is the Director of the National Reactor Innovation Center at Idaho National Lab. Dr. Finan?

DR. FINAN: Good morning, Mr. Chairman and NRC Commissioners. Thank you for the opportunity to speak with you today.

My name is Ashley Finan, I'm the Director of the National Reactor Innovation Center, or NRIC, a national DOE program focused on accelerating demonstration of advanced reactors in partnership with the private sector.

Next slide, please. This country has a track record of rapid demonstration of advanced nuclear energy when faced with an urgent need. The imperative we face today is climate change, alongside other energy and security priorities.

Recent policy actions noted on this slide have directed the work that both DOE and NRC are doing today in this area. While the history is encouraging, today's effort is not identical to the past.

One important difference today is that instead of a single Atomic Energy Commission we have separate agencies for R&D and regulation in the DOE and NRC.

The ability of the DOE and the NRC to work in a coordinated way while implementing their individual missions and fulfilling their separate duties will be pivotal to the success of demonstration efforts.

The policies, MOUs, and meetings that are in place to affect that coordination are a hopeful sign for the same reason that this Commission meeting is especially important.

I'll next speak about the Advanced Reactor Demonstration Program and NRIC in more detail. Next slide, please.

The ARDP, or Advanced Reactor Demonstration Program, is a DOE program to demonstrate advanced reactors in the next seven years.

It has three funding pathways that are aligned with technological maturity level.

Next slide, please. Ten awards have been made under the program including two commercial demonstrations on the left with TerraPower and X-energy, a startup to occur within 7 years, and a 50-50 cost shared arrangement in that public-private partnership.

And then five risk reduction awards have been made on a longer timeframe of about 12 years, and these 5 projects include at least 2 experimental or demonstration reactors.

And then there are three advanced reactor concept awards that are not on a specific demonstration timeline. Risk reduction and advanced reactor concepts awards are 80-20 cost shares between private industry and the Federal Government.

NRIC supports these important projects as well as other demonstration efforts by industry's partners.

Next slide, please. Our vision at NRIC is to support the demonstration of at least two advanced reactors by 2025 to restore U.S. nuclear energy leadership. And then to see commercial advanced nuclear available by 2030 to contribute to abundant clean energy.

Next slide, please. We are working to achieve that vision through our mission to inspire stakeholders to empower innovators to test and demonstrate their technology, and to deliver successful outcomes through efficient coordination of partners and resources.

And we show that mission in a circle because those

functions are interrelated. As we empower innovators to test and demonstrate technology, we'll be able to deliver successful outcomes.

And I'm confident that as we deliver successful demonstration reactors, that will captivate and inspire the stakeholders who are counting on affordable clean energy for future.

Next slide, please. We aren't doing that alone. Along with GAIN, the Gateway for Accelerated Innovation in Nuclear, we're helping innovators cross the bridge from concepts to commercial products.

And we do that in large part by helping them access the capabilities in the DOE NE R&D campaigns and support programs, which I've catalogued in my back up slides for your reference.

Next slide, please. In addition, NRIC is working to empower innovators with some capabilities specific to demonstration, including the Demonstration Resource Network of test beds in existing facilities, demonstration sites outside of existing DOE facilities, and experimental facilities to help them do that.

We also have programs in regulatory risk reduction, in economic risk reduction that I'll cover on the next slide, we have a virtual test bed for demonstration modeling and simulation, and a resource team that helps innovators access national lab expertise.

Next slide, please. I want to describe our efforts relative to costs and markets because there are some regulatory implications. We want to ensure that the technologies that we help demonstrate are economic and scalable to meet our global challenges.

We're developing and open-sourcing digital engineering tools and approaches in service of that, that have been proven to reduce costs and improve schedule in other industries.

We're also developing a public-private partnership to demonstrate some advanced construction technologies that could similarly improve construction cost outcomes.

And we're partnered with the Integrated Energy System's cross-cutting technology development program to develop a demonstration of integrated energy systems alongside advanced reactors.

And we plan to issue a request for expressions of interest in the coming weeks.

And then we're in the initial phases of a construction readiness project to help address some of the key challenges related to nuclear energy project management.

These are areas where we're in communication with the NRC staff and see promising opportunities. Next slide, please.

Finally, NRIC is a national program and central integrator for partners and collaborators. We are here to connect innovators with key DOE resources to prepare key DOE resources and to look around corners to help the private sector execute successful projects.

While DOE and NRC's priorities may appear to be in tension at times, I think most recognize that in fact, in the long term they are mutually reinforcing.

Because technological advancement drives improved

safety performance and strong technology-inclusive safety requirements both drive technology advancement and open up new deployment possibilities, and improve characteristics.

As values of the cooperative spirit we've seen in the NRC staff, I commend the Commission's attention to this topic, I appreciate the opportunity to participate, and I look forward to my fellow panelists' presentation as well as the Q&A session.

Thank you.

CHAIRMAN HANSON: Thank you, Dr. Finan. Next we'll hear from Mr. Clay Sell, the Chief Executive Officer of X-energy.

Mr. Sell?

MR. SELL: Thank you very much. Chairman Hanson, Commissioners Baran, Caputo, and Wright, thank you for this opportunity to make my inaugural appearance before the Commission.

It's my privilege to address this panel representing the women and men of X-energy on the subject of advanced reactor regulatory preparedness. If you can go to my second slide, please?

I'll just make an inquiry, can you all see my presentation? There it is, if you'll advance to the next slide, please? Thank you very much.

The Department of Energy's advanced reactor demonstrations, the program demonstrations represent an incredible opportunity to prove our nation's ability to deploy advanced nuclear plants well before the end of this decade.

It will also allow us to build on the progress of the Next

Generation Nuclear Plant program to improve the efficiency, the predictability, and timeliness of regulatory reviews.

X-energy's commercial plant design is the Xe-100, a generation 4 design that integrates the pebble bed, high temperature, gas-cold technology demonstrated internationally at the AVR and THTR reactors in Germany.

It builds upon prior domestic operating experiences from Fort St. Vrain, the extensive NRC pre-application engagements on General Atomic's modular HTGR nearly three decades ago. And most recently from DOE's Next Generation Nuclear Plant design.

X-energy also produces its own coated particle fuel, we call it TRISO-X. We leveraged a substantial DOE investment in this technology to manufacture the highest-quality radium oxycarbide TRISO fuel in the world.

We will be submitting our license application for an expanded commercial facility later this year and have near-term pre-application activities that build upon the progress from the advanced gas reactor program.

Please go to the next slide. Previous NGNP regulatory engagements greatly benefit our Xe-100 licensing activities. The challenges shown in the left column were raised during those previous interactions.

And since 2014, resolutions have been developed that are ready for application now. For example, the acceptance of mechanistic source term and safety design approaches that utilize multiple barriers to retain fission products is provided through various Commission papers and

staff requirement memos.

There is now a systematic method for determining how to select licensing basis events for safety analysis and a risk-informed method of classifying structures, systems, and components and their treatment during operations.

Both are provided through guidance developed in the licensing modernization project. And I'll ask the slide driver to keep my slides up, please.

Finally, we have a performance-based approach to developing the emergency preparedness requirements associated with a small reactor found in draft NRC guidance in the forthcoming rulemaking.

And some examples on the right highlight that there will also be challenges ahead.

We recognize that a risk-informed application requires risk insights from a maturing probabilistic risk assessment, a tool that must be developed progressively through the design iterations. The Xe-100 incorporates security designs to delay and deter aggressors, an approach that we intend to ensure is aligned with the forthcoming security rule making.

And finally, the Xe-100 also uses high-assay low-enriched uranium for its fuel supply so access to HALEU is of critical importance to us.

We continue to work with domestic supplier centers with the Department of Energy with other global suppliers and our peers in the advanced reactor community to ensure this resource will be available and ready for use for near-term deployments like ARDP and beyond.

Next slide, please. We feel confident the Xe-100 and TRISO-X fuel can be reviewed efficiently and operate safely today. Specific to your request for today's meeting, I'd like to make the following comments regarding fuel fabrication.

We implement quality control measures to ensure we can reliably credit fuel particle performance using our proprietary improvements to the TRISO fabrication processes developed through the AGR program.

We also benefit from the certification of the Versa-Pak 55 shipping container for transport of our finished product to any site in the U.S., and we anticipate across the border to prospective Canadian customers.

The performance of TRISO-coated particle fuel has been demonstrated through the AGR program and approved via the recent EPRI topical report for use in licensing.

X-energy has plans to supplement these findings with information from our own development program to confirm our TRISO-X fuel performance.

Lastly, we are following the NRC endorsement of ASME code for high-temperature reactors, representing the development of material and design approaches for HTGR components commensurate with their safety significance.

The first Xe-100 units will also have additional capability to monitor system performance and evaluate pebbles to enhance the operating experience of our TRISO-X fuel.

The plant's initial test program also provides opportunity for

both operational and safety testing. You can take the slides down.

The Xe-100 represents an evolutionary design that builds upon a substantial amount of research, development, and experimental data.

We believe the amount and pedigree of operating experience collected over decades of HGTR operations are sufficient to safely license our design today.

We look forward to continued engagements with the NRC on these topics, thank you again for the opportunity to testify and I look forward to your questions later in the hearing.

Thank you.

CHAIRMAN HANSON: Thank you, Mr. Sell. Next we'll hear from Mr. Simon Irish, the Chief Executive Officer of Terrestrial Energy U.S.A. Mr. Irish?

MR. IRISH: Good morning, Mr. Chairman and Commissioners.

I want to thank the NRC for this opportunity to participate in this Commissioner's briefing on preparedness activities for advanced reactors, particularly with respect to fuels and materials.

Can I have the first slide, please? I'd like to start with a brief summary of the IMSR Power Plant. The IMSR is a 452 megawatt thermal, liquid-fueled and cooled, molten fluoride salt reactor, operating in the thermal spectrum with a graphite moderator and a pool-type design.

The reactor system operates at near atmospheric pressure and delivers 600 degrees thermal energy by molten salt loops for either

electricity generation or direct supply to industrial process heat applications.

The plant electrical output is 195 megawatts electrical, implying a 44 percent thermal efficiency, which is critically important for economic performance.

The IMSR power plant is fueled with standard assay low-enriched uranium, i.e., less than five percent enriched over its entire life of 56 years. The plant operates on a seven-year fuel cycle, which is aligned with the IMSR core unit replacement cycle.

After a seven-year period of operation, the entire sealed IMSR core unit is taken offline and replaced with a new core unit.

Next slide, please. Terrestrial Energy has submitted the IMSR for regulatory review activities in both Canada and the United States.

It's important to note that we have an ongoing dialog with multiple U.S. and Canadian utilities, and their input and advice has been invaluable in informing our regulatory approach.

In Canada, the IMSR was engaged early in the Canadian Nuclear Safety Commission's vendor design review process, or VDR. In 2017 Phase 1 of the VDR was completed and Phase 2 of this process should be completed later this year.

Concurrent with the VDR, Terrestrial Energy has developed technical information to support an application in the U.S. for a standard design approval of the IMSR core unit under Part 52.

To that end, Terrestrial Energy has been submitting technical white papers on the IMSR as part of its U.S. regulatory engagement

plan with the NRC.

To the maximum extent practical for the NRC activities, we are leveraging the ongoing engineering and regulatory work that has been accomplished in Canada for the vendor design review process.

The key lessons learned from this approach is that early engagement with the regulator is essential to establishing the firm regulatory understanding of the requirements of the technical information necessary to obtain regulatory approvals as part of any future license application.

Given the timing of the ongoing VDR activities undertaken by the Canadian Nuclear Safety Commission, as well as the numerous ongoing pre-licensing activities for the NRC, the IMSR is well placed to support the NRC-CNSC memorandum of cooperation and demonstrate a successful two-country licensing approach.

While the protocol for cross-border interaction between the regulators on important regulatory topics can be complex, it is our belief that this regulatory collaboration initiative represents an opportunity to substantially reduce regulatory burden in preparing applications for both the U.S. and Canada, while maintaining country-specific regulatory requirements and, hence, regulatory sovereignty.

As you may know, the NRC and the CNSC are reviewing a topical report on postulated initiating events and we believe this review effort is progressing well, and look forward to further topical reports that we will be submitting jointly to both regulators.

We look forward to continuing collaborative interactions

over a broad spectrum of topics for both regulators. Next slide, please.

Fuels and material qualification programs are defined by our basic engineering program at the IMSR power plant and are well underway and scheduled to be completed later this year.

The overall design program includes physics, thermal hydraulics, materials, and chemistry. In the case of IMSR, chemistry includes fuel qualification. The design of the IMSR is derived from technology developed in the 1960s within the molten salt reactor experiment ats Oak Ridge National Laboratory.

The MSRE laid the practical technological foundations for the IMSR reactor design. To address the differences between the IMSR and the MSRE reactor designs, Terrestrial Energy has defined a technology development program to identify and address gaps. And that program is being executed today.

Although the IMSR is a fission reactor, just as all operating reactors are today, the fuel qualification process for the molten fluoride salt that is both coolant and fuel is markedly different from the qualification process for traditional solid reactor fuels.

The same is true for the operating environment and the unique requirements it places on materials selected for use.

Ongoing programs associated with IMSR material and fuel development and qualification include corrosion studies, the confirmation of the fuel's thermophysical properties, computational modeling of the fuel salt's thermophysical properties, and conducting integrated studies to confirm the

gathered knowledge concerning corrosion of alloys, salt-graphite interactions, fission product behavior, mass-heat transport in an integrated system, and operational and accident conditions including IMSR radiation levels.

Within the fuel and chemistry program, contracts associated with the fuel salt qualification have been placed and work is underway with qualified suppliers, such as Argonne National Lab, Virginia Tech University, Canadian Nuclear Laboratories, ENGIE Laborelec, and others.

Specific to the IMSR core unit moderator, the second cycle of graphite irradiation at the Petten reactor in the Netherlands has been completed late last month.

All of the testing is proceeding well and results are as anticipated. The alloy testing program is addressing the corrosion characteristics of the chosen alloys in the fuel salt environment throughout the seven-year life of the core unit, as well as associated stress corrosion cracking behavior. Specific phenomena studied will include galvanic temperature-driven, impurity-driven and flow-accelerated corrosion. Corrosion kinetics will be identified based on the measured data.

This corrosion kinetic data will then be used as input in the design of corrosion loop tests. These tests will be helpful in addressing outstanding corrosion phenomena and we believe they place us in a good position to address these phenomena in our respected applications to the CNSC and NRC.

Both fuel and material qualification programs are well underway and on schedule to support the first commercial deployment of the

IMSR power-plant as early as 2028.

NRC staff are welcome to review these ongoing processes as part of our collaborative review activities.

Next slide, please. I know this is rather a brief review and only touched upon several topics in our entire development and deployment effort. I will be glad to answer any specific questions the Commissioners may have.

Thank you very much.

CHAIRMAN HANSON: Thank you very much, Mr. Irish, I appreciate your presentation. Next, we'll hear from Mr. Steven Kuczynski, Chairman, President, and Chief Executive Officer of Southern Nuclear Operating Company.

Mr. Kuczynski?

MR. KUCZYNSKI: Good morning, Chairman Hanson, and Commissioners Baran, Caputo, and Wright. Thank you for the opportunity to brief you today on Southern Company's perspective on advanced reactors as well as our investments in advanced reactor technology.

Next slide, please. Thank you. Southern Company has committed to reducing our greenhouse gas emissions to net zero by 2050.

We believe that new nuclear generation can be central to enabling a net zero future by powering reliable, resilient, and dispatchable production of clean electricity, hydrogen, and process heat required to decarbonize the economy.

Even as we are nearing completion of the AP1000 reactor

at Plant Vogtle, we continue to pursue the next generation of nuclear technologies.

Southern Company is committing resources to research and development that supports availability of advanced reactor deployment concurrent with any future retirements or decarbonization requirements.

We are pursuing technologies expected to be competitive with natural gas combined cycle generation, post-combustion carbon capture and solar generation, and energy storage.

We expect advanced reactors to reduce capital investment, time to construct an operating and maintenance cost as a result of their inherent and simpler safety cases, which will also make it possible to expand siting options and open new markets to nuclear power.

The high-temperature heat that many advanced reactor technologies generate is an especially attractive attribute that can be used to decarbonize industrial processes, power clean hydrogen production, and manufacture clean, synthetic fuels.

Advanced reactors can transform many industries and take decarbonization beyond the 45 percent of the economy that can be electrified. Southern Company sees tremendous potential for advanced nuclear technologies to provide clean, safe, and affordable energy for customers and for the nation.

Next slide, please. Southern Company closely follows ongoing development and progress in the advanced reactor industry and has partnered with TerraPower in developing its Molten Chloride Fast Reactor

technology, or MCFR.

MCFR is one of the most advanced Generation 4 nuclear technologies under development.

By combining a homogeneous liquid fuel in a fast spectrum with the molten salt coolant, the MCFR results in superior performance, safety, and economic benefit, providing flexible, highly efficient, clean electric power generation and carbon-free hydrate processes and thermal storage.

The DOE has selected Southern Company to lead a team to design, construct, and operate the Molten Chloride Reactor Experiment under the DOE's Advanced Reactor Demonstration Program risk reduction pathway, which focuses on the design and development of the advanced reactor technologies with a potential to be licensed and deployed within 10 to 12 years.

The recently awarded Molten Chloride Reactor Experiment will be the world's first critical fast spectrum salt reactor and is an integral part of the comprehensive MCFR technology development program led by Southern Company.

The Molten Chloride Reactor Experiment project will span approximately five years and provide vital nuclear data and operational experience that informs the design, licensing, and operation of a an MCFR demonstration reactor that is expected to be operational by the early 2030s.

Southern Company's R&D and organizational lead managed the effort in its collaboration efforts that include TerraPower and a number of private companies, national laboratories, and universities, and

maintain the momentum begun in 2015 by Southern Company, TerraPower, and several partners to develop and demonstrate key MCFR technology under the DOE advanced reactor ARC award.

Next slide, please. As I mentioned earlier, advanced reactor technologies have the potential to provide safe, clean, and affordable energy to meet the future energy demands of our customers and our nation.

Southern Company believes that to take full advantage of the promise offered by these designs an agile, predictable, and resilient regulatory framework is needed.

Such a framework will enable a consistent, coherent, and timely establishment of technical and oversight requirements across a range of different advanced reactor designs, while providing flexibility, regulatory predictability, and a streamlined oversight approach throughout the lifecycle of the reactor.

We believe that integrated and holistic risk-informed, performance-based regulatory framework is the best option to efficiently achieving these desired attributes.

Therefore, we support the Commission's role in developing the foundation for such a regulatory framework through deploying the proposed Part 53 by 2024.

Southern Company has been working collaboratively with DOE, NRC, and other industry stakeholders to build confidence in the effectiveness and practicality of a risk-informed, performance-based regulatory framework for many years.

For example, one of our most recent initiatives is the Licensing Modernization Project, or LMP, a DOE cost-shared project.

LMP has established an optional risk-informed performance-based methodology for developing and assessing the reactor safety case within a Part 50 and Part 52 application.

LMP is also intended to be optional guidance for use of future risk-informed performance-based rule that forms the foundation for transitioning to an integrated, holistic risk-informed performance-based regulatory framework for the license, inspect and enforce NRC requirements.

This holistically modernized regulatory framework will enable all the stakeholders to move more effectively and utilize the enhanced safety margin of advanced reactors to better serve our nation through the lifecycle of a plant.

In conclusion, Southern Company believes advanced reactors have an important role in decarbonizing the economy and is fully engaged in investing in advanced reactor technology development and regulatory modernization.

Thank you for the opportunity to participate in today's meeting, I look forward to any questions you may have.

CHAIRMAN HANSON: Thank you very much for that. Next we'll hear from Dr. Todd Allen, Senior Visiting Fellow with Third Way.

Dr. Allen?

MR. ALLEN: Good morning, Chairman Hanson, fellow Commissioners, thank you for inviting me to participate in this hearing. If you

can go ahead and go to my second slide, that would be fine.

So, where are we in the deployment of nuclear energy? Well, a little history, between the 1970s and 2000s we proved that we can deploy nuclear energy quite rapidly, 30 plants per decade over a 3-decade period.

We've plateaued since, although we've increased the operational efficiency of the existing plants. But we're at this point now where some question are we at a cliff or inflection point?

Will we run the existing plants and that's it, or will we build a new generation?

I think very strongly that the combination of addressing climate change, the clean energy jobs that go along with that, influencing international norms in nuclear energy, and supplying a resilient grid through using multiple technologies will keep us deploying advanced nuclear energy.

Next slide, please. And you can click to the end so we see everything, thank you. So, about five years ago you saw a very strong recognition of advanced reactor companies.

So, many states were doing things to extend the life of the existing reactors. At the same time we saw a number of new companies, a few of them are talking today that had different ideas about how to move the technology forward.

This was paralleled by federal programs to support those, you've heard some of those this morning from Dr. Finan, like GAIN or NRIC, the new RBE programs.

Legislation has moved forward in a bipartisan way to support the deployment of these advanced reactor companies. We have NGOs advocating for advanced reactor, we have the NRC working very hard to be ready for these companies.

So, what's different? Next slide, please. I think what's different is the potential uses of the technology.

I go back 50 years when I was a kid and it was simple, we built gigawatt-scale electric plants and we sent out electricity through transmission and distribution lines to the homes.

But now there are opportunities because of sources that come on and off the grid that are variable, different energy products, different deployment scenarios, the need or anticipated need for significantly more electrification.

And so what's different is we need different products beyond just gigawatt-scale electricity, and that's what the advanced reactor companies are bringing in multiple, multiple ways.

Next slide, please, there we go. And so I think we'll see the following things being important, we'll see nuclear energy concepts that are aimed at different uses other than just gigawatt-size electricity production.

We see a couple of those today.

We'll see sites proposed that are different, people will want to deploy these in different locations than we did with first-generation light water reactor technologies.

I think the technological approaches that will be used will be

different. It may get value through updating more frequently than we may have seen in the past.

And so at a big picture I think we'll see more ideas brought forward at a faster pace, and so the more regulatory system can create performance-based metrics rather than size-specific, site-specific, or technology-specific approaches, the more efficient the system will be at responding to these new ideas, which I think are positioned to improve our society.

And so I will leave it at that, I thank the Commission for inviting me today and I look forward to the Q&A.

CHAIRMAN HANSON: Thank you, Dr. Allen. Next we'll hear from Mr. Steven Swilley, Deputy Chief Nuclear Officer and Senior Director of Research and Development for Nuclear at the Electric Power Research Institute.

Mr. Swilley?

MR. SWILLEY: Thank you, Chairman and Commissioners, for the opportunity to discuss this important topic on the future of commercial nuclear power.

This morning I will briefly discuss two topics, technical readiness and the role of private-public partnerships.

Next slide, please. On the subject of technical readiness, I've got three projects here to talk about, near-term advanced reactor deployment.

On the Owner-Operator Requirements Guide for advanced

reactors, EPRI has developed and published a new high-level platform for communicating and understanding advanced reactor design attributes, capabilities, and requirements among end users, developers, and other stakeholders.

This guide is intended as a flexible living technology and mission-inclusive framework to enable alignment of advanced reactor design attributes with customer wants and needs, support customer evaluation of those new designs, communicate advanced reactor capabilities and attributes to regulators and other stakeholders, and facilitate introduction of events, designs to new customers and new markets.

If you're familiar with the EPRI utility requirements document, you may think of this Owner-Operator Requirements Guide as a prequel to that document.

On safety and design, advanced reactor developers pursuing design certification and/or licensing sometimes face challenges in developing a safety case, and those designs may have limited to no commercial operating experience or incorporate novel design elements and/or have unique source terms.

A system engineering and establish qualitative and semi-quantitative process hazards analysis methodology provides a bridge to quantitative probabilistic risk assessment that are progressively applicable and adaptable to the design maturity and level of detail, and capable of generating event trees and fault trees for quantitative risk assessments.

This methodology has been briefed to the NRC staff on several

occasions as well as to the ACRS during the Licensing Modernization Project, which did lead to NEI 18-04 for risk-informed, performance-based technology-inclusive guidance for Non-Light Water Reactors licensing basis development.

On advanced reactor materials, as advanced reactors move towards higher temperatures and harsher operating conditions than the existing light water reactors fleet, material options are needed for the various reactor types.

EPRI has developed material gap analysis reports for each of these reactor designs and is focused on supporting not only the ASME code material qualifications, but also capturing and understanding the environmental effects such as irradiation and corrosion that are needed to support regulatory approval.

One pillar of this initiative is focused on coordinating the efforts within the industry to meet deployment timelines. Next slide, please. On the subject of public-private partnerships, I've got three examples to highlight.

The first one is on additive manufacturing. EPRI, along with the Department of Energy, Oak Ridge National Laboratory, Westinghouse, and Rolls Royce collaborated with component fabricators and the supply chain to develop the first ASME code case for additively manufactured components.

We performed a series of round-robin testing on three different components from five different fabricators, thus established repeatability in the process and giving confidence to the industry and new

technologies.

This was not just one organization performing all of the work and holding that expertise. We focused on the technology transfer, which is a key value of public-private partnerships.

This first-of-a-kind code case will pave the way and provide a pathway methodology for other materials and similar technologies to follow.

On the SMR Advanced Manufacturing Demonstration Project, working with the Department of Energy, Oak Ridge National Laboratory, Nuclear AMRC from the UK and NuScale, we are reinventing the supply chain by focusing on three game-changing technologies for the nuclear power industry.

The first one is powdered metallurgy hot isostatic pressing, also known as PMHIP, is really an alternative to forging. It represents a reduction in the time and cost and also opens up a domestic supply chain opportunity.

Electron beam welding is factory fabrication with significant reduction in weld times to the tune of a 90 percent reduction. Diode laser cladding, an automated process reducing labor and lead times while also reducing material cost.

Large-scale demonstrations are essential in moving technologies from laboratory to the real-world applications, providing end users confidence of deployment.

Scaling is made possible with public-private funding where one private organization may not have the appetite to take on that risk.

My final example is TRISO fuel performance topical report. TRISO structural isotropic coated particle fuel provides the foundation for inherent safety and high-temperature operation in advanced high-temperature reactors, including helium and molten salt cooled designs.

A public-private effort was initiated to support advanced reactor developers and designs by leveraging and locking in existing high-quality fuel qualification data resulting from close coordination among EPRI, the Department of Energy, Idaho National Laboratory, and the High-Temperature Reactor Technology Working Group.

On August 11, 2020, the NRC published its final safety evaluation report approving the use of the EPRI TRISO topical report for future applicants. EPRI subsequently published the revised approved technical report in November 2020.

The NRC's early agreement to conduct an off-fee basis review of the resulting topical report based on its generic applicability was essential to the successful outcome of this effort.

The resulting approved topical report should increase the efficiency of the safety review process for design certification and license applications to come.

This concludes my remarks, thank you.

CHAIRMAN HANSON: Thank you very much, Mr. Swilley. And last but certainly not least we'll hear from Dr. Ed Lyman, Director of Nuclear Power Safety at the Union of Concerned Scientists.

Dr. Lyman?

DR. LYMAN: Good morning, Chairman Hanson and Commissioners Baran, Caputo, and Wright. UCS really appreciates the opportunity to present our views on this very important topic today.

Next slide, please. So, last month UCS released a report on the landscape of Non-Light Water Reactors called Advanced Isn't Always Better. And we looked in particular at sodium-cooled fast reactors, high-temperature gas-cooled reactors molten salt fuel reactors.

And overall, our research does not substantiate the notion that any of these Non-Light Water Reactors actually meets the NRC advanced reactor policy statement expectation that they will have clearly enhanced safety margins.

And as a result, none of these designs warrant the broad weakening of regulatory standards that the NRC is considering. Next slide, please.

Now, I want to focus my remarks on the two Advanced Reactor Demonstration Program demonstration reactors that the NRC has licensing authority over. Now, we believe that the congressionally-mandated timeline for startup of these reactors by 2027 is very aggressive.

And in fact, the Department of Energy itself characterizes the timeline that way.

The program calls for commercial demonstration plants to be built and operated by that date. Now, although what that actually means is somewhat ambiguous, my reading is the clarification of those facilities is that they will essentially be identical to subsequent commercial units.

Their goal is to produce electrical power on a commercial basis and serve as models for subsequent commercial use.

And Mr. Levesque of TerraPower said last month that a big piece of the company's private investment contributions to that program will be the revenue stream.

And Mr. Sell testified before Congress also last month that we are demonstrating a full-scale commercial plant, just like the plant we will sell.

Next slide, please. So, why is this a problem?

We see this as a problem because the NRC has not yet determined whether the criteria for plants with passive safety features or additional advanced reactor qualities, as specified in 10 CFR 50.43(e), can actually be licensed without having acceptable testing prototype plants, for either the Natrium sodium fast reactor or the Xe-100 high-temperature gas-cooled reactor.

And during pre-application reviews in the 1990s, the NRC staff expected that both those types of reactors would have prototype testing before a design certification.

Now, if the NRC does decide for the advanced reactor demonstrations a prototype testing of some sort is necessary, it really must soon determine what type of testing will be required, what format it will take, and for how long.

And the NRC's obligation is on maintaining public health, safety, and security. And its licensing timetable has to be focused on that.

It should not compromise its standards to meet an arbitrary and unrealistic schedule imposed by Congress.

Next slide, please. In our view, we do not think that either of the demonstration plant designs are mature enough to be safely, securely, and reliably deployed as commercial reactors on the current schedule.

This applies not only to the basic reactor design but as well the fuels and materials that would be needed.

And that is because the past demonstrations of those designs were not sufficiently representative of the current designs to provide adequate data to support NRC's licensing decision.

So, we think prototype testing will be needed and, again, the form of that prototype testing needs to be determined by the applicant in discussion with the NRC.

If you deploy these plants commercially without doing that testing, that could have safety impacts.

For instance, if the goal of those projects is really to generate revenue, there may be pushback from the licensees to carry out safety testing that may be necessary before full commercial operation.

And the other way around, if you take the deployment of the Xe-100 at Columbia Generating Station, for example, the potential for grid requirements to put constraints on the operation of that plant could require operation in modes that may not have been fully demonstrated, load following or cycling.

Next slide, please. So, I don't have time to go through this

but this is just some examples of aspects of the Natrium design, which differ significantly from the prior U.S. demonstration of this technology, which is the EBR2.

I'd like to focus on the sodium void worth, which is the inherent feedback against power increases in the reactor. The EBR2 had a negative void worth because it was a very small reactor and the Natrium will be positive.

Why is that important? Next slide, please.

It's because a reactor with a positive sodium void worth cannot be characterized as passively safe, and I'm quoting here from the NRC's pre-application report for the PRISM reactor from the 1990s, where it disputed characterizing this reactor as passively safe because of the potential for a positive reactivity excursion on a rapid basis, sodium boiling and potential for core melt and disassembly.

Next slide, please. And for that reason, the NRC did argue that a PRISM prototype was needed and at that time DOE had committed to doing such a prototype.

One important aspect is whether a conventional containment building would be needed and NRC argued that the absence of such a containment building would have to be demonstrated through transient testing on the safety testing requirement side.

Next slide, please. And similar arguments apply for HTGRs, especially the pebble bed, which has not been demonstrated in the United States and prior demonstrations in Europe were not totally successful

and also had many different characteristics.

Next slide, please. One example of a safety concern with that design is the potential for the Xe-100 at 200 megawatts thermal, which is the target of our level for the demonstration to exceed the 1600 degree TRISO safety limit in the most severe design basis accident.

That's a well-known safety limit that should not be exceeded and will need demonstration eventually to determine whether or not those safety limits are challenged. Next slide, please.

And you have to dig out that fact from a report in a technical journal to learn that the safety limit would be exceeded. Next slide, please.

And again, in the 1990s the NRC staff believed that a modular high-temperature gas-cooled reactor of a prismatic block design, which was demonstrated in the United States would still need another prototype demonstration again to verify features of the design that would allow the design not to have a conventional low-leakage containment.

Next slide, please. Now, the NRC itself has raised the issue of early engagement with advanced reactor licensees on the need for prototype testing through regulatory engagement plans.

There's very little public information about the NRC's interaction with the current Advanced Reactor Demonstration Program applicants on these issues, which clearly have to be sorted out immediately to determine the extent of prototype testing and how that would be carried out.

Next slide, please.

So, to conclude, we believe that the ARDP demonstration

plants will probably need to have additional safety features and operational constraints during prototype testing phases that last five years or more or until the reactor has achieved equilibrium operation.

And the additional safety features may need to include conventional containment buildings, safety-grade emergency diesel generators and active backup emergency cooling until the passive features of those designs are demonstrated.

I will stop there.

CHAIRMAN HANSON: Thank you, Dr. Lyman, and thank you to all of our panelists this morning for what were really illuminating and helpful presentations.

We'll begin with questions from the Commission with Commissioner Baran.

COMMISSIONER BARAN: Thank you all for joining us today and for sharing your perspectives. I want to get your thoughts about NRC's Part 53 rulemaking, which will establish much of the regulatory framework for advanced reactors.

This is a major effort and it's going to involve a lot of hard work, creating a risk-informed, performance-based technology-neutral framework that can work for molten salt reactors and high-temperature gas-cooled reactors, micro-reactors, and reactors of several hundred megawatts.

I think everyone agrees that's challenging. I've been following the public meetings and it sounds like there's a fair bit of vendor interest in deterministic options, particularly from micro-reactors.

That's different than what I think the NRC staff was initially envisioning, which was more of a PRA-focused licensing modernization project type approach.

For those of you who have been actively participating in the Part 53 public meetings, do you think there should be options that are more deterministic under the rule?

And if so, what do you think that should look like?

MR. KUCZYNSKI: This is Steve K., I'll touch on this a little bit as my presentation touched on Part 53.

We do feel Part 53 is another option and we think the pathway of performance-based, risk-informed really envelopes all of the available technologies going forward. And we think that's an important pathway to continue.

I think the level of PRA varies between technologies and I think that can be overcome. And we would probably not lean forward on being more deterministic in Part 53. We do think that Part 50/52 has some optionality if individual companies want to go that direction.

COMMISSIONER BARAN: Thanks, Steve, do others have thoughts on that?

MR. IRISH: Commissioner Baran, I'll add to comments from Steve Kuczynski. From our perspective, our strategy today is the standard design application under Part 52, Subpart E.

That is our strategy today.

We are contributing, though, as a vendor to the efforts to

move forward with Part 53. Until rulemaking has occurred on Part 53, it's going to be difficult for us to incorporate Part 53 into our licensing plans.

We anticipate, though, that Part 53 has the potential to be important to the licensing activities in subsequent years.

With respect to specifically your question as to the difference between probabilistic safety analysis and deterministic safety analysis, obviously, Part 53 is focusing on probabilistic safety analysis.

I had certainly never viewed Part 53 to be exclusively probabilistic safety analysis and we'd probably have to defer an expert comment to my colleagues to determine exactly where, from our perspective, the optimal allocation is between probabilistic and deterministic safety methods with respect to our system.

COMMISSIONER BARAN: Thanks, any other thoughts on this?

DR. LYMAN: Yes, if I may? Sorry, I'll defer to Clay, actually.

MR. SELL: I'll be very brief. As I previously stated, due to the timelines required under the ARDP demonstration program, we're going to pursue either Part 50 or Part 52 approach.

Nonetheless we really are interested and remain engaged in Part 53 program, I mean developement program, we do see it, quite honestly, as a once-in-a-generation opportunity to truly transform the regulatory framework for a multiplicity of designs.

I will share with you just from a Chief Executive standpoint,

the rush to a rule perhaps might lead to us missing the truly transformational opportunity with the Part 53 rulemaking.

Specifically to your question, Commissioner Baran, it's our view that an appropriately designed Part 53 should allow for both deterministic and probabilistic risk analysis approaches to regulation.

Thank you.

COMMISSIONER BARAN: Let me throw one other question in here for folks who had the deterministic question too.

Do you think the rule should require an advanced reactor applicant to have a PRA? Maybe Steve Kuczynski, do you have a view on that? If you were going to apply it to Part 53, should you have to have a PRA?

MR. KUCZYNSKI: Yes, our view I think is consistent with how the rule has been developed of many years.

We think the risk-informed quantitative measures are the best way to, I'd say, provide clarity, certainty, and predictability in a regulatory framework.

So, we do think that PRA is integral to that effort. So, yes.

COMMISSIONER BARAN: Any other thoughts on this before we move on to other questions?

Really, what I'm trying to get at is when I read the transcript, I was surprised that there was a significant level of vendor interest and something more deterministic.

I wasn't really expecting that. I didn't have a negative reaction to it, but it was surprising to me.

I'm not hearing a lot of that on the panel today but any other thoughts on deterministic approaches and whether or not applicants should be required to have a PRA under the rule?

DR. LYMAN: Yes, if I may say something? I share your surprise that after so much advocacy for risk-informed, performance-based regulation, which clearly implies a heavy reliance on PRA, that the Nuclear Energy Institute and other stakeholders seem to be backing away from that.

Now, I personally am skeptical about how far a PRA can actually be used in the licensing a plant that has no operating experience.

But I do think Part 53 offers the opportunity to solve or address some of the gaps in licensing of the existing fleet that were highlighted, for instance, in the Fukushima Near-Term Task Force. Where we're finally addressing the issue of how you come up with a consistent way to classify a design basis and beyond-design-basis accidents and apply appropriate treatment.

So, I think there has to be a deterministic element to licensing new reactors.

The danger that I see in what's being proposed is that it's quasi deterministic that some in the industry would like to be able to make, essentially, a deterministic finding which is really implicitly risk-based.

In other words, what's the maximum hypothetical accident? So, there's an implicit quantitative aspect there because you are, essentially, saying what is so improbable that you don't need to consider it?

And so I think the danger there is not having a clear

standard of how you make a deterministic source term calculation, for example, as in Part 50.

If you maintain consistent safety requirements with Part 50, you need to have a deterministic approach that will provide comparable protection of public health and safety.

COMMISSIONER BARAN: Thanks, Ed. In the public meetings some stakeholders are recommending that the rule contain high-level language with a lot of detail and guidance.

Are you all envisioning a lot of technology-specific guidance, for example, detailed liquid sodium cooled, fast reactor guidance? And if so, who do you see developing that guidance?

Anyone want to weigh in on that one? How high-level should the language be and then how much should we have in guidance? And who should put that guidance together?

MR. KUCZYNSKI: Commissioner, when we think about the quantitative measures, it is designed I would say, in our view, to promulgate high-level performance objectives and then obviously, there's work to do define what those are and what they cover and what those levels will be.

And that then allows a framework for developers, not only those that are in progress today that may choose 53 or those over the next decades as technology evolves to know what the overall performance objective, and not have to be extremely specific about every technology.

Then you leave it to the developers to develop a technology,

present the safety case, and demonstrate to the NRC how those performance objectives are met.

And to us, that provides predictability but it also is agile enough to be technology-inclusive, which I think ultimately is what we want to try to achieve.

COMMISSIONER BARAN: Thanks, Steve, I think it's a good point. Reading the transcripts, it's not surprising to me that vendors would prefer a lot of flexibility in how they demonstrate the safety of the reactor designs.

I do worry, though, that if every safety case takes a unique approach, that could impact regulatory predictability. There is a trade-off between flexibility and predictability.

Thank you all for sharing your views, there's a lot of work left to be done on this rulemaking and I look forward to continuing the conversation.

Thanks.

CHAIRMAN HANSON: Thank you, Commissioner Baran. Commissioner Caputo?

COMMISSIONER CAPUTO: Good morning, I'd like to start by thanking all of our speakers for coming today and contributing their perspectives on this very high priority topic for our agency.

I think I'd like to continue on with Commissioner Baran's line of questioning. I know we've heard several views and Mr. Sell in particular mentioned on one of his slides about the alignment of PRA expectations.

But I'd like to hear from Mr. Swilley, you mentioned how a qualitative and systematic process hazards analysis could be a bridge to a quantitative PRA.

Considering that a lot of these technologies may not have the operational experience significant or systematic enough to generate the high-quality level 3 PRA, how do you see your process hazards analysis being that bridge to help these technologies develop?

MR. SWILLEY: Thank you, Commissioner. It's really going to upon the maturity of each design as each developer comes in.

The hazards process and operability analysis has been demonstrated in particular in the chemical industry for how do you go through each area and identify what are the risks, what are the hazards, what are the consequences?

Even though you don't have the quantitative information to establish it at that point.

And the methodology is really intended to be iterative so if you have a developer, instead of trying to tackle everything at once, if you go through this process you can define what are the gaps, and what are the additional information or R&D that needs to be established to create that quantitative information?

And the methodology that we put together actually matches up this process to the inputs necessary to develop a PRA. So, as you go through this process, it helps you identify the inputs and then identify where the gaps are in developing the PRA.

So, it's a difficult question to answer in that it's going to be somewhat varied and different depending upon the maturity of each design and the information that is available and the information that would need to be developed.

COMMISSIONER CAPUTO: So, help me understand a little bit more.

Through that process, is it likely that you would encounter situations where you might find subtopics, per se, that would be easily bounded and might be more suited towards a deterministic answer, simply because it's simpler and more straightforward, while other topics should be more exhaustively examined through a PRA approach?

MR. SWILLEY: Certainly, and I think that same process could help prioritize what are those significant challenges that maybe you go the deterministic route because it's more defined and simpler to implement.

But then in the end, maybe the PRA approach gives you more flexibility in the approach that you use to solve the problem.

And again, it's a methodology, there are some case studies we've gone through, there are more case studies to go through that people can go back and look and determine how to apply this.

So, I try not to be cagey but without specifics, it's difficult to answer.

COMMISSIONER CAPUTO: Fair enough, I think in general one of the struggles that we'll face throughout this process is the balance between clarity and reliability versus flexibility.

And if we look at taking an approach that is focused solely on PRA, the approach may be simple but the execution may be complicated.

And so I would just encourage the staff to be flexible in terms of how they go about distinguishing those issues.

My next question is to Dr. Allen and Dr. Finan. Both of you have actively contributed to advanced reactor policymaking for many years.

So, in addition to the bipartisan support evident in Congress for several years, President Biden's American Jobs Plan includes advanced nuclear in its priorities and in its clean energy standard.

Secretary Granholm also emphasized her support for deploying advanced nuclear reactors during her confirmation hearing. Do you expect this level of administration support to accelerate the development and deployment of advanced reactors?

DR. FINAN: Thank you for the question. Todd, I'll take my take at it and then you can go ahead. Commissioner Caputo, I really think back to Dr. Michael Ford's doctoral dissertation at Carnegie Mellon when I think about this topic.

He studied DOE NE's past programs in detail and his conclusion, one of them, was that successful innovation in nuclear requires urgency, political support, and a coherent strategy consistently implemented.

And my own doctoral dissertation made some similar recommendations, so I do think that the recent emergence of the coherent and consistent strategy coupled with urgency is foundational and auspicious. And the literature suggests that continued commitment will be critical to

successful outcomes in that strategy.

COMMISSIONER CAPUTO: Thank you. Todd?

MR. ALLEN: Thanks, Ashley.

And I think I would agree, I think that we've seen momentum that started around 2015, it's crossed multiple administrations but it keeps becoming more consistent.

And I think that the drivers I mentioned before addressing climate change and a more resilient grid, I don't think these go away, I think they continue on. And so I think we're just building support for federal programs that in many ways will parallel what we did with renewables.

There's a combination of R&D plus federal programs that drive improvements in the systems through partnering with commercial industry. And I think the external drivers that want clean energy technologies don't go away.

So, I think the trends continue.

COMMISSIONER CAPUTO: Dr. Allen, I have another question for you and for Mr. Kuczynski.

Dr. Allen, you mentioned how more ideas will be brought forward at a faster pace and Mr. Kuczynski, you mentioned the need for a regulatory framework to be resilient and manage state-of-the-art changes without unnecessary burden, delay, or disruption.

Would you provide a little more detail on your views of how exactly the regulatory framework should address that challenge?

MR. ALLEN: I can go first, and I think I just would go back

to some of your previous comments or questions that you asked.

I think that you will see multiple different technologies and I think what's important is if you lock down on just one approach, PRA or deterministic, it will be hard.

And so I think the answers that were previously given, maybe by Mr. Swilley, relative to a flexibility depending on the vendor while maintaining a set of standards is probably going to be necessary.

And some of these companies will not make it, commercial competition will eliminate them, but I do think we'll continue to see that variability in the concepts.

MR. KUCZYNSKI: Commissioner, thanks for that question.

A little insight on what we mean by resiliency, I think we're looking at as these technologies emerge and if you think about it over the next 10, 20, 30 years and reflect back on the existing fleet, how do we handle, both as a licensee and a regulator, different safety issues that arise through the deployment of these technologies?

And there's always that balance between does the licensee take initial ownership and manage the overall response to that safety issue as we see in the programs in our industry?

Or is it the NRC that has the complete control and helps guide those? And I think we've seen over the years a transfer in some areas to where licensees using probabilistic methods have been able to update our ability to address some of these programmatic issues.

So, I think going forward, we would continue to support that dialogue between the balance between the licensee's responsibility to address programmatic safety issues that may come up in the future.

We think there's an opportunity to continue the trend to where the licensee has more direct ownership and the NRC provides that high-level oversight on how a licensee does respond.

So, that was kind of what our thinking was around the resiliency, and obviously, today we don't know exactly what issues we will face in the future as new technologies develop and are deployed.

But the framework about how we address those is what we're talking about in Part 53 in the rule.

COMMISSIONER CAPUTO: Thank you.

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

COMMISSIONER WRIGHT: Thank you, Mr. Chairman. It's good to see everybody in person here at the table who I'm sure cannot wait until we can get the panel here in person as well.

So, first off, I'd like to extend my appreciation to all of these speakers today.

We covered a lot and I had a lot of questions, some of them have been addressed in some way, so we may plough over a little bit of ground that we've already ploughed just to maybe get a little bit more clarity.

Mr. Sell, I want to talk to you first and I've said before and it's no surprise, I think my colleagues share the same view that the NRC

doesn't want to be a barrier to advanced reactor technology.

Instead, consistent with our mission, we want to work efficiently and effectively to license technologies that are coming before us.

So, in terms of our efforts to do so, I wanted to kind of get your thoughts on the progress of Part 53 of the rulemaking so far, as discussed, the goals for it to be performance-based and risk-informed.

Do you believe we at the NRC are implementing that approach thus far?

And if not, are there areas where we could look to leverage such an approach and areas where it would not be appropriate to do so? Could you maybe address that for me?

MR. SELL: Commissioner Wright, would you mind restating your question for me? I want to make sure I understand it correctly.

COMMISSIONER WRIGHT: So, we're going through the Part 53 rulemaking and we're having regular meetings and stuff on this with industry.

And as we're going forward on this, it's purposed to be both performance-based and risk-informed. So, do you believe that we in this process at the NRC are implementing that approach thus far?

And if we're not, are there areas where we could look to leverage such an approach? And are there areas where we probably ought not do so?

MR. SELL: My sense, Commissioner Wright, thanks for the question and the opportunity to comment on it.

I'm just going to speak to you from the level of the Chief Executive based on the feedback that I'm getting from both our industry supporters, my licensing team, other people that I listen to.

My sense is that perhaps the early deadline that's been imposed by the Commission has forced some decision-making, forced an approach more exclusively towards probabilistic risk assessment that perhaps will not result in the rule that we all hope for or what we all hope to achieve in Part 53.

That's my sense. Now, I have not been involved directly or engaged in these discussions, it is something I'm quite interested in but in our case, we are intensely focused right now just from an operational licensing standpoint on our pre-engagement activities, on the ARDP, and on our pre-licensing activities.

And then we anticipate most likely a Part 50, possibly a Part 52, application associated with the Energy Northwest demonstration project.

So, that's where all of our operational focus is now.

It's certainly my view that a rush to an early Part 53 rulemaking may allow us, through good intentions and a focus on getting it done early, to miss the opportunity to create a truly transformational rule that will stand the test of time and be attractive for future licensing activities beyond the late '20s era that we're focused on now.

COMMISSIONER WRIGHT: Thank you. Simon, maybe, do you want to address that at all, the Part 53 issue?

MR. IRISH: Yes, Commissioner Wright, I had a few more

comments on Part 53. We are providing feedback to Part 53, I'm listening to comments today regarding the importance of getting this right.

A risk-informed framework I think is critically important to maintain the flexibility of the regulatory process. And that flexibility is important to support innovation.

The innovation process itself is uncertain and the start of the innovation process of any technology is very difficult, almost impossible, to predict looking forward 10 years what the successful commercial outcomes may be.

So, I support getting Part 53 correct, I support the principles very much, the principles and the importance of a risk-informed framework. I see it as a tremendous effort because that risk-informed framework would have to embrace the many possible pathways for a licensee in the future, it's a lot of work.

I suspect that work will need to be done there. Our focus concurrently, as I said earlier, is on the standard design application of the Part 52 and perhaps using certain regulatory arguments, such as exemptions, for certain systems and components as methods to move that application forward.

So, I hope that provides a little bit more detail and color, Commissioner, to your question.

COMMISSIONER WRIGHT: Right, thank you so much. I heard that Mr. Sell's company, X-energy, is doing, what is it, Part 52(e) and then you all are looking at either 50 or 52?

We're trying to develop 53 so everybody can come under that and try to figure out how we don't make it so cumbersome that nobody uses it. So, I'm trying to really get to what do we need to try to encourage the development and inclusion of?

And I think from what I've been hearing in the last few weeks, people are concerned about it just being too big, too cumbersome, too wieldy, and not providing the avenues that might be necessary.

We've heard and I'm actually going to ask this in the next panel as well but we've heard feedback that it's too restrictive and not flexible enough.

Some had suggested that there is a need for some that could use LMP and then others maybe a graded PRA approach, and then maybe some using maximum credible accident as part of it as well.

Or even the IAEA standards. So, I'm just wanting to make sure that knowing that you're looking at a different avenue to do stuff and our goal is not to go license to exemptions or to put license conditions on, we want to try to get this rule right. So, I'm trying to figure out are there other ways that we can get there that the staff is not considering already? And what do we need to do to make sure that we can get that done in a timely way.

I hear everybody saying we don't need to go too quickly and if the deadline is ‘24, ‘27 and we don't hit it, it's okay as long as we get it right. And I do subscribe that we need to do this right.

So, does anybody want to maybe add or pitch in, make any comments on things that we can encourage or that you all can encourage, the

staff?

Do you think that give and take is taking place? That's kind of what I'm trying to get at, based on what I've been hearing.

MR. KUCZYNSKI: Commissioner, this is Steve, I'd like to make some comments on your general question there. I think we all want to make sure that we get it right and it's a quality product and it serves the long-term benefits of the developing technology.

I think what we need to recognize, I don't think it's unexpected that as we get further into the rulemaking and the issues become clearer that the intensity of the dialogue ramps up from all the stakeholders.

I think that's a good sign. I think our challenge is how do we reconcile and manage that input and not allow a issue or two issues to stall the overall progress?

I think it's going to require just some enhanced level of engagement and elevation of issues so that we don't get stuck and go forward.

I don't necessarily align with the rule as rushing, I just believe you do decide to set a target to try to achieve and when you find barriers, then as leaders we have to determine are there ways to navigate through those challenges to still meet a deadline and a target?

Obviously, if that's impractical, then the target potentially moves but I got involved in this is 2015 in the Advanced Reactor Working Group and we're talking about nine years later.

I just don't fundamentally see that as a massive rush to get into a rule. My experience is organizations work to whatever the expectation

that the leadership sets and if we set 2029, it will be 2029.

If we set 2024, then I think our challenge is to orchestrate and manage our way towards a product. And I think the real key here is I think there's going to need to be expanded interaction and elevation of tough issues.

And so both all the stakeholders will have to align and get all the information available and same with the staff and the NRC to just make sure we're able to navigate our way through some of these more challenging issues, which I'm not surprised are there as we get towards more definition around the rule.

COMMISSIONER WRIGHT: Okay, anyone else?

(Simultaneous speaking.)

MR. IRISH: I'll defer to my colleague on the panel.

DR. FINAN: Thank you, Simon.

Commissioner Wright, I would add for context that while Part 53 may not apply to these demonstration projects, as you're probably aware, there are dozens of other advanced nuclear companies pursuing development of demonstration projects down the line.

So, I think we should keep in mind that it is not just short term and long term. There are a number of companies coming through the pipeline who could be supported by Part 53 depending on the timing.

COMMISSIONER WRIGHT: Thank you for making that point. That's where I was trying to go, so thank you for that. There was somebody else?

DR. LYMAN: Yes, may I say something, please?

COMMISSIONER WRIGHT: Sure.

DR. LYMAN: Hello?

COMMISSIONER WRIGHT: Yes?

DR. LYMAN: So, my impression, although I don't agree with some of the avenues that the staff is taking and the development, I think they're doing a very good job in trying to respect the requirements and the responsibilities of the NRC to again maintain a consistent level of safety with the current regulations.

Because we think that the NRC is missing an opportunity to require the next-generation of nuclear plants to be clearly safer than the current generation but that's not your policy.

But you have to maintain a clear and consistent nexus to the current requirements and I think the staff is trying to do that while accommodating the wishes of the industry.

But the NRC's fundamental commitment is, again, to adequate protection of public health and safety.

Your responsibility is not to make things easier for applicants if that could compromise your ability to maintain your statutory requirements to the public, responsibilities to the public, and so I urge you to keep that in mind, at the forefront as you go forward.

COMMISSIONER WRIGHT: And if I could make one last comment, Mr. Chairman? Just to be clear, I know there was a 2027 deadline and I think we went aggressively more to 2024 deadline.

I'm not suggesting that we go past 2027 at all, I'm just saying that if it takes us past 2024 to get it right then I want to be sure we get it right. Thank you.

CHAIRMAN HANSON: Thank you, Commissioner Wright.

And this is the peril of going last, certainly not least of all because my colleagues have covered all the topics.

But also the ways in which they've covered them and their characteristic insights in an erudite manner, particularly the crux of some of these things with regards to probabilistic versus deterministic approaches, flexibility versus predictability versus clarity, ensuring that both applicants and the public understand how we're approaching these things, how we're making our adequate protection determinations.

So, I want to thank my colleagues for that and given the ground that we've ploughed, I'm going to take this in a slightly different direction. My first question is really for Mr. Sell and Dr. Finan and Mr. Swilley, and I wanted to ask about HALEU.

And given how it is being used not just in the X-energy design but a number of other designs that are by vendors that are interacting with the NRC, can you share where we stand with respect to data needs to support criticality safety code validations for expected fuel storage and transportation designs?

And to what extent are DOE, industry, EPRI, and others working to address any data gaps that we might have?

MR. SELL: Chairman Hanson, I'll start to say that I think

the tremendous work that's been done in the advanced reactor program and in NGNP over the last 15 has really phenomenally filled most, if not all, of the data gaps as it relates to the issues you've identified.

We still plan to do some confirmatory irradiation both at MIT and Petten that will provide additional validating data for a particular fuel design.

And as it relates to the issues of storage and criticality and transportation and issues that you identified, I think the work of the last 15 years has served us very well.

CHAIRMAN HANSON: Interesting. Dr. Finan, Mr. Swilley, are you guys participating in this at all?

DR. FINAN: Chairman, I'll add one comment, which is broader regarding HALEU but I do think that it's become clear that the availability, the deconversion and the fabrication, and all of these aspects of the use of HALEU is critical path in some sense to advanced reactor demonstrations.

And there's been a renewed commitment to developing and finalizing a strategy around HALEU. There's a lot of work to be done and we've made great strides but we need to keep pushing that forward to ensure that we have the supply and we're ready to use it for these advanced reactor demonstrations.

CHAIRMAN HANSON: Thank you.

MR. SWILLEY: From the EPRI perspective, I can't add much more than that. We are delivering roadmaps in gaps and working

through the data gathering actively. Nothing more to add.

CHAIRMAN HANSON: Dr. Lyman, did you want to add something here? I thought I saw your hand up. Okay, as a follow-on to that, there's been some interaction between the NRC and the Canadian Nuclear Safety Commission.

And there's a memorandum of cooperation on advanced reactors and on some of the designs that we're talking about today. But I was intrigued by a comment, Mr. Sell, that you made in passing about moving HALEU across the U.S.-Canadian border.

And in addition to reactor collaboration or cooperation that we're having with the CNSC, do members of the panel have any suggestions for the NRC with regards to other fuel cycle aspects or cooperation with CNSC that you think we should be having or would be useful in this area?

MR. SELL: Chairman Hanson, I don't know if you eliminated me from the potential answer set or included me in the potential set. I think there is tremendous opportunity between the CNSC and the US NRC. As some of the panel may know, we are actively in the DVR Phase 1 and 2 process with the Canadian regulator right now.

We have identified a specific area to test appropriate collaboration between the two regulatory bodies as it relates to the specific code standard for reactor pressure vessel.

I think there are further opportunities for the CNSC and the US NRC to work together to actually make cross-border transportation of material through the approved Versa-Pak 55 that the NRC has done to

coordinate on that and actually make appropriate transportation protocols across the border easier to operate and actually improve the efficiency of transportation cross-border.

Thank you.

CHAIRMAN HANSON: Thank you. Anyone else want to jump in on that?

MR. IRISH: Chairman Hanson, I'll maybe comment as well. It doesn't relate specifically to HALEU.

Our system also uses, as I said earlier, five percent standard assay but the cross-border point I think still holds with respect to your engagement with the Canadian Nuclear Safety Commission and it reflects I think what we all know is a structural feature of the Canadian nuclear industry.

Namely, it's use of natural uranium or near natural uranium and an enriched moderator. So, fuel supply of enriched uranium and the cross-border requirements to support that fuel supply through the packaging I think is a topic that is very cross-cutting in the industry.

CHAIRMAN HANSON: Thank you, Mr. Irish, I appreciate that. All right, changing tact just a little bit here, Dr. Lyman, I was intrigued by your presentation.

As we go about licensing advanced reactors, we have a series of what I would call information streams. We have experimental data from the national labs, we have some operating experience from potentially analogous reactors around the world and in the United States, we have modeling and simulation.

And then there is, as you pointed out, prototypes, operating experience as, in your view, and I hope I'm characterizing this correctly, as a major or the primary information stream that's necessary for licensing for really ensuring adequate protection. But it did raise for me the question about how you see these other information streams and their relevance and the role they could also play in making the adequate protection determinations? Particularly I'm interested in modeling and simulation and experimental data.

How do you see those factoring in, in addition to, or in some cases maybe in lieu of operating experience through a prototype?

MR. IRISH: Chairman Hanson, I'd say with respect to modeling and simulation, the industry today in regard to their innovation efforts are supported by modeling and simulation tools that are extraordinary in their sophistication and capability compared to the case 25 years ago or even 15 years ago.

So, computer power has provided a tremendous set of analytic capabilities. So, modeling and simulation will continue to be invariably the central feature of reactor development going forward.

And that modeling simulation I think can assist tremendously with respect to assessing performance of component systems and subsystems.

Obviously, with modeling and simulation one will need to go and demonstrate either through single tests or integrated tests the solid performance of the model. And that program will be the responsibility of the vendor.

CHAIRMAN HANSON: Thank you. Dr. Lyman? Are you there? I don't know, Dr. Lyman, are you on mute? I saw you.

DR. LYMAN: I'm not, can you hear me?

CHAIRMAN HANSON: I can hear you now.

DR. LYMAN: Sorry, I don't know what happened.

So, on the issue of modeling and simulation, it's very design and issue-specific and I'm not saying that there aren't some aspects where there are insufficient validation and clarification of codes. But to be able to answer some of those questions within the necessary precision that you needed.

But it's not clear yet that there's a systematic approach for the Advanced Reactor Demonstration Program designs that are before you, but to be able to make those decisions.

And so that's why I'm arguing, certainly I haven't seen enough public information to be able to make a judgment myself whether or not some of that data is adequate.

But again, as I point out in our report, in the talk, there are significant differences with regards to past demonstrations to the extent that I don't think -- I would be skeptical that you could really get to the necessary precision you need to make your safety determinations without the kind of prototype testing that the NRC staff called for back in the 1990s.

Because nothing really has changed much since then because computational tools may have improved but they're only as good as the information you have to validate them. And that I think is an outstanding

gap.

So, a big part of the prototype testing is to be able to provide information to validate those tools so you can predict accurately any regimes you can't test in. For instance, you're not going to be testing to failure but you do need to have severe accident tools that will give you the data.

And just looking at Fukushima and the fact that Light Water Reactors have many decades of operating experience, very well developed PRAs, and yet, the MELCOR code doesn't do a very good job in trying to replicate what actually happened in Fukushima.

So, even with the best developed tools and data, there are still gaps in these modeling simulations. Thank you and I'm sorry about the feedback.

CHAIRMAN HANSON: Not at all, technical difficulties, it's been the story of the last 13 months plus for everybody so no worries.

Thank you, Dr. Lyman. One last question for Mr. Kuczynski. Is the molten chloride reactor experiment a prototype?

MR. KUCZYNSKI: I'd say it's a difficult question to answer at the moment. There's a lot of different definitions of what people consider a prototype and what we should get out of that.

Our intent is to demonstrate the critical aspects through this upcoming phase. I think the future of what else will go after this current phase I think is still up for some dialogue and debate.

But we certainly feel that we're willing to go prove over the next five to seven years will be incredibly important to informing the safety

case for MCFR.

CHAIRMAN HANSON: Great, thank you all very, very much.

Thank you to our panelists, Dr. Ashley Finan, Mr. Clay Sell, Mr. Simon Irish, Mr. Steve Kuczynski, Dr. Todd Allen, Mr. Steven Swilley, and Dr. Ed Lyman, thank you all very much for being with us this morning for this really illuminating conversation.

The Commission is going to take a five-minute break and we'll reconvene at 10:45 a.m. to hear from the staff panel. Thank you.

(Whereupon, the above-entitled matter went off the record at 10:41 a.m. and resumed at 10:47 a.m.)

All right, welcome back, everyone. We will now have the NRC staff panel to continue the discussion of NRC's preparedness for advanced reactors through regulatory engagement and research partnerships.

The staff panel will be kicked off by our Executive Director for operations, Margie Doane, followed by staff panelists. Margie, the floor is yours.

MS. DOANE: Okay, good morning, Chairman and Commissioners.

We are pleased to be here today to provide an update on the agency's activities to support advanced reactor preparedness through regulatory engagement and research cooperation.

As discussed during the external panel, there is significant

industry interest in employing new advanced reactor technologies to meet our future national energy needs.

Regulatory preparedness is a critical part of the staff's plan to meet the challenges that the NRC will face in reviewing applications that support this deployment.

Advanced reactor preparedness is a priority for the NRC's safety and security mission. Our ongoing preparedness efforts will continue to require forward thinking and planning using risk-informed insight as we identify and resolve challenges associated with the industry's proposal to use new and emerging technologies.

As you've heard in the previous panel, we are actively engaged in ensuring our regulatory framework, staffing, and agency infrastructure are ready for new licensing review of advanced technologies.

Staff across the agency are engaged in incredible work, some of which we will be highlighting today. The Office of New Reactor Regulation, NRR, is actively engaging with applicants and preparing for regulatory reviews.

Early coordination, dialogue, and pre-planning are key to facilitating more effective, predictable licensing review processes.

To this end, the staff will describe the progress that has been made in issuing guidance that provides flexibilities for advanced reactor design differences in areas of risk-informed licensing and environmental reviews.

For example, last month the staff issued a design review

guide on instrumentation and controls to further modernize the review of advanced reactor applications by making it more technology-inclusive, risk-informed, and performance-based.

The Office of Nuclear Regulatory Research, or Research, is preparing technical bases to support the use of new technologies and updating its existing tools to support confirmatory safety analysis of advanced designs.

Recently, the Advisory Committee on Reactor Safeguards has endorsed the staff code development plan for advanced reactors. This endorsement has provided staff confidence in its approach.

The Office of Nuclear Material Safety and Safeguards, NMSS, is preparing for licensing reviews associated with the front and back end of the advanced reactor fuel cycle to support deployment with operators and vendors already.

This year, NMSS has completed technical reports identifying information gaps and challenges for advanced reactor fuels. The office has also completed a package certification to support advanced reactor fuel transportation.

All of these offices are engaging with stakeholders across the federal government, industry, and with international organizations to enhance our work in advanced reactors.

We are also actively and openly engaging with members of the public to provide transparency and opportunities to engage in our advanced reactor regulatory activities.

In describing the work of the staff since our last meeting on advanced reactors, I would be remiss if I didn't talk about the ongoing impacts of the COVID-19 pandemic on our work over the last year.

Importantly, the COVID-19 pandemic has affected our ability to have in-person audits, meetings, and interactions with applicants and our domestic and international counterparts.

In-person engagements have proven highly effective in resolving complex issues over the years and we look forward to a time when we can have these engagements again.

But there has also been a silver lining in our virtual environment.

As has many of NRC programs, the pandemic has forced us to develop transformative approaches to overcome these challenges, which have yielded enhanced benefits for reaching more stakeholders and sometimes allowed for better sharing of information by leveraging technology.

For example, the NRC now routinely draws over 100 participants to its periodic stakeholder meetings on advanced reactor topics. The use of virtual platforms allow us to reach more stakeholders and efficiently share information during those meetings and interactions.

Next slide, please. Now let me turn to our most important asset, our people.

Pictured on the slide are the faces of NRC staff from several offices supporting the advanced reactor program. Their energy and dedication are key to the agency's success.

Indeed, to meet the regulatory challenges for advanced reactor licensing and regulation, we must continue to remain focused on the recruiting and retaining of staff that are necessary to meet the challenges of today and tomorrow.

Importantly, we will need to ensure they have the right training, skills, and abilities to accomplish the challenging work in front of us.

Our modern, strategic workforce planning and our forecasting tool we refer to how signposts and markers enable us to better assess and respond to the dynamic external environment that affects our work and identify skill gaps and workload trends.

A strategic look at the next several years has allowed us to effect change now to ensure we have a stable and well-trained workforce in years to come. In addition, our engagement with the Department of Energy and the National Labs is proving very effective for providing training and development opportunities for our staff in enhancing our capabilities to respond to the evolving advanced reactor environment.

Next slide, please. Now I'd like to introduce the panelists who will describe the agency's activities to support preparedness for advanced reactors.

Rob Taylor, the Deputy Office Director for New Reactors in NRR will provide an overview of the agency's preparedness activities and licensing efforts.

And I couldn't help but notice the Commission's interest in Part 53 so I think you'll be hearing a lot about that this morning.

Ray Furstenau, the Director of the Office of Research will provide an overview of the agency's research activities that support the agency's confirmation capabilities and external engagement.

Next, Raj Iyengar, the Chief of the Component Integrity Branch, also in the Office of Research will provide insight into research on technologies supporting advanced materials and manufacturing.

Marilyn Diaz, a chemical engineer in the office of NMSS, will provide insight into the regulatory preparedness of the nuclear fuel cycle for advanced reactors.

And finally, Michelle Hayes is the Chief of the Advanced Reactor Technical Branch in NRR and she will discuss how research and international activities support ongoing and future licensing deployment of these advanced reactor technologies.

This concludes my opening remarks, I'm going to now turn the presentation over to Rob Taylor.

MR. TAYLOR: Thanks, Margie. Good morning, Chairman and Commissioners, it is a pleasure to be here today to talk about the staff efforts to transform and prepare for the review of new and advanced nuclear technologies.

During my discussion today, I will talk about how those transformation efforts are ensuring safety and security, how our activities are aligned to support national advanced reactor priorities, and how we leverage domestic and international partnerships to achieve success.

Next slide, please. Pictured in this slide is an image from

our redesigned advanced reactor webpage, which showcases the pillars of our efforts, including our activities to transform our workforce, modernize our tools, and develop flexible review strategies among others.

In late 2020, we unveiled our redesigned webpage by offering a more modern look for members of the public, providing a streamlined experience, and making it easier to obtain information about the staff's advanced reactor activities.

The newly redesigned webpage also includes information for stakeholder engagement such as public meetings, workshops, and other activities.

We recognize that preparing licensing for advanced nuclear technologies is not just about the right regulatory framework. It takes a commitment of the right people, the right safety focus, the right communication strategy, and the right dedication to our mission and stakeholders' interests.

We recognize that this is a journey and the evolving landscape and diversity of new technologies will challenge us to declare complete preparedness.

Nevertheless, we can say that our activities ensure that we can rise to the challenges that we will encounter and that we will have the necessary capabilities in our people, regulatory framework, and analytical tools to adapt and advance.

To help us confidently do our jobs even better, our principles of good regulation will continue to be our guide for identifying opportunities to be innovative, to take a fresh look at how we provide efficient, reliable, and

open approach to our activities.

Next slide, please. As we prepare for licensing the next generation of nuclear technologies, it is critical that we keep one eye focused on how external factors are driving an evolving landscape and growing interest in deploying these technologies.

Over the last year, we have seen the landscape for advanced nuclear technologies steadily evolving and we are adopting and changing with it. This interest is driven in part by strong Congressional and Executive Branch support for deploying advanced nuclear technologies.

The Nuclear Energy Innovation and Modernization Act and the Department of Energy's Advanced Reactor Demonstration Program have been tremendous catalysts for advanced reactor technologies.

Recently, DOE announced the recipients of awards related to two demonstration projects to be operational within five to seven years, five risk reduction recipients, and three advanced reactor concept recipients.

DOE’s efforts are spurring substantial engagement from vendors with the NRC. Today we anticipate receiving 13 or more applications by 2027 for advanced and small modular reactors and new research and test reactors.

These include applications for various licenses including construction permits and operating licenses, combined licenses, standard design approvals, and design certifications.

These applications could eventually result in six or more operating licenses by 2027. We are now actively engaged with 10 entities in

various stages of pre-application activities.

Also, we are interacting with other entities on additional potential applications in various degrees of design maturity and expect that the numbers will change as our discussions progress.

Over the last two years, we've completed reviews of 17 topical reports or white papers for 7 vendors and have another 20 from 8 vendors under review.

We are seeing strong pre-application engagement from many vendors and we continue to encourage it.

We're also anticipating additional submittals as vendors ramp up their pre-application activities. Our focus remains on early engagement and resolving issues that will facilitate timely and efficient licensing when applications are submitted.

Next slide, please. Now I'd like to pivot and discuss the staff's efforts to support these national advanced reactor priorities.

The NRC staff continues to make substantial progress in executing its vision and strategy for advanced reactor readiness by achieving the activities outlined in the six implementation action plans pictured on this slide.

Still, work remains to ensure that we can successfully review the variety of technologies on the horizon. During my presentation I will cover some of the implementation action plan activities while my fellow panelists will cover others during theirs.

As part of the NRC's efforts to build a 21st-century

workforce, we are using strategic workforce planning and signposts and markers initiatives to respond to the evolving environment we work in to better identify skill gaps and work with trends.

A strategic look at the next several years has allowed us to effect change now to ensure that we are prepared with a stable workforce in the years to come. Especially in this evolving landscape, our staff continues to be our most important resource.

We are investing in a new generation of nuclear safety leaders through the Nuclear Regulator Apprentice Network, some of whom actively work in the advanced reactor program.

In addition, we're also investing in to ensure that our current workforce has the skills needed to execute our mission through training and developmental opportunities.

In addition to preparing our workforce, we continue our efforts to prepare a technology-inclusive risk-informed regulatory framework, also known as Part 53.

We recognize that a flexible review process that includes key guidance is critical to that effort. Within the last two years, the NRC has published or endorsed nine guidance documents such as the licensing modernization project and have another 12 under development, many of which are planned to be issued in the next two years.

We recognize the guidance development will remain a critical focus area, especially in support of Part 53, and we remain committed to working with stakeholders to identify and develop and needed additional

guidance.

In addition to the guidance, we're enhancing our analytical tools and capabilities to review enhanced technologies, endorsing new standards from advanced reactors, resolving key policy and technical issues, and progressing and completing a variety of rulemaking activities related to Part 53, advanced reactor environmental reviews, emergency preparedness, and physical security.

Next slide, please.

We cannot be successful on any of the activities I have been discussing unless we simultaneously foster strong working partnerships with domestic and international counterparts to ensure that we both share experience and knowledge and collaborate where possible to enhance our regulatory processes and decision-making.

I will cover some of them here while Ray will cover our research partnership with DOE during his presentation, and Raj will talk about our efforts on consensus codes and standards.

Over the last year the list of stakeholders with whom we are engaging has continued to grow as more vendors and technology developers have approached us. More stakeholders are participating in our public activity and more international counterparts have expressed interest in our activities.

We are implementing new approaches to our engagement in a variety of our initiatives. For example, we are continuing our readiness activities by prioritizing the new Part 53 rulemaking to complete it by October

2024.

The staff is committed to a framework that achieves the goals of the Commission's advanced reactor policy statement and the NRC's principles of good regulation.

To provide better visibility and clarity on the staff activities, we are implementing a novel approach of releasing preliminary rule language to facilitate public discussion with applicants, vendors, non-governmental organizations and others about the direction and content for this rulemaking.

This early engagement highlights areas requiring enhanced dialogues to iteratively risk-informed the rule language to ensure clarity and reliability.

The staff has already received 65 unique comment submittals, each of which may include multiple individual diverse comments on preliminary language. We received constructive and good feedback on aspects of the rule such as those related to the role of probabilistic risk assessment, defense in-depth, and the tiering structure.

As we evaluate the input we are receiving, the staff is committed that the preliminary language will remain open for ongoing dialogue and we expect further revisions to the subparts as the staff progresses towards development of the proposed rule. These efforts will ultimately help us prepare a better rule that will accomplish the desired outcomes. On the international front, the NRC and the Canadian Nuclear Safety Commission, or CNSC, have worked constructively with various advanced reactor vendors to identify projects and establish a framework that could support coordinated

safety reviews of key design aspects for some advanced technologies.

The NRC and CNSC's memorandum of cooperation on advanced reactors and similar technologies, is a first-of-a-kind endeavor and continues to be an utmost priority for both agencies.

Our teams have made meaningful progress, successfully overcoming many challenges and aggressively proceeding with projects in greater harmony and focus.

This includes implementing first-of-a-kind virtual staff exchanges to maximize collaboration that has put us on track to successfully complete some initiatives and produce first-rate products this year.

Michelle Hayes is going to provide additional perspectives on this collaborative effort and other international activities during her presentation.

We recognize that actively engaging with all stakeholders will bring various new ideas and approaches that will inform and shape how we undertake our regulatory activities.

Next slide, please. 2021 is shaping up to be a defining year for the NRC to deliver on the safety and security mission, and our vision to make the safe use of nuclear technology possible.

At the beginning of my presentation today, I mentioned that we need to ensure that we have the right regulatory framework and the right people, safety-focus, communications, and dedication.

Our efforts on each of these fronts will continue in 2021 and we will only be successful if we partner with our stakeholders. Now, I'd like

to turn it over to Ray Furstenau.

MR. FURSTENAU: Thank you, Rob. Good morning, Chairman and Commissioners.

The Office of Nuclear Regulatory Research provides the technical advice, tools and information to support the NRC's safety and security mission. Rob shared with you a growing interest in advanced reactors, as did the previous panel. And as you know, it's a diverse array of technologies.

Research had a "be ready' mantra and I'd like to share with you some of the activities we are doing in coordination with our licensing office partners to help ensure NRC's readiness for licensing innovative reactor technologies.

Next slide please. Slide 12. I'm not seeing the slides but I'll assume they're there. For Slide 12 the Office of Nuclear Regulatory Research has focused on developing codes and tools endorsing technical standards and in developing our staff capabilities.

A key element of our readiness strategy is the development of codes and analytical tools to support confirmatory analyses that may be used in advanced reactor licensing actions.

Our code development plans include analytic capabilities to assess fuel performance, reactor safety, source terms, severe accidents, siting and safety of the front and back end of the fuel cycle.

Through this fiscal year we will have completed plans that document the specific codes the staff planned to use. Gaps in those code

capabilities and data needs, validation needs and code development tasks for different reactor and fuel technologies.

Through this process we gain feedback from our licensing offices, the ACRS, and the public, to help align our priorities and next steps. To support timely regulatory reviews, the staff is developing what we call reference plant models based on publicly available information on several of the advanced reactor designs.

The value we see in developing these models is to exercise the codes, identify the bugs in the codes, and operability issues before the licensing applications are submitted. Thus reducing the amount of time needed to prepare design-specific plant models.

These reference plant models then can be adapted based on pre-submittal interactions and design information in the licensing application submittal.

We are planning a number of public workshops later this year to show in full, plant source term calculations used in our codes, SCALE and MELCOR for example, for three of the reference plant models.

The office is also engaged in the important work of engaging with industry on developing the standards and technical bases that support safety assessment of new reactor designs. Specifically, we are working towards the development and endorsement of standards for high temperature materials and probabilistic risk assessment standards for advanced reactors.

Lastly, as Margie and Rob both stated, and I will also emphasize, our talented staff is key to our success. To that end, we are

focused on hiring new talent and further developing existing staff talent.

We also leverage the enormous capabilities that exist within the national laboratories, commercial contractors, and universities.

Slide 13 please. Under the umbrella of the Nuclear Energy Innovation Capabilities Act of 2017, and our accompanying MOU with the DOE on nuclear energy innovation, we continue to closely coordinate, and cooperate, with our DOE colleagues and the national laboratories on advanced reactor technologies.

This slide captures many of the programs and areas relevant to the agency's preparedness for advanced reactors. Along with our DOE, R&D and deployment counterparts, we have instituted several MOUs and MOU addenda, fostering increased coordination and cooperation.

Our discussions help to identify and close technical gaps and identify areas for resolution, in addition to leveraging opportunities to cooperate in activities. For example, modeling and simulation capabilities and the Nuclear Energy Advanced Modeling and Simulation Group.

Data needed to support ATF fuel concepts, advanced manufacturing technics and the versatile test reactor, which is sodium cooled fast test reactor being built and authorized by DOE.

The advanced reactor demonstration program, the National Reactor Innovation Center and nuclear science user facilities.

Slide 14 please. On this slide are three research approaches I would like to highlight. The DOE-sponsored Accelerated Fuel Qualification Program, or AFQ is an innovative approach to new reactor fuel

development that couples physics-informed advanced nuclear fuel performance modeling and simulation, with accelerated fuel testing aimed at significantly reducing the cost and time for the qualification of new fuels.

NRC staff have been observers during the AFQ workshops, thus building expertise on new methods being developed to test, qualify and potentially fabricate new fuels that could be used in advanced reactor designs.

Besides DOE and NRC participants include national labs, fuel and reactor developers, and even NASA contractors who are helping to develop new fission systems for space applications.

The imagine you see on the slide, the one with the penny and the small uranium nitrite particles shown along the edge of the penny, illustrate a mini fuel irradiation concept being used in the high flux isotope reactor at the Oak Ridge Nuclear Lab. This concept, and the HFIR, are ideal for rapid separate effects testing of large numbers of small specimens under a diverse set of isothermal conditions.

This approach produces large data sets that help in the development and validation of fuel performance codes.

Under our international collaborations with the closure of the Halden Reactor in Norway, fuels and materials irradiation testing alternatives had to be identified to address the loss of that irradiation capability.

The newly-created NEA Framework for Irradiation Experiments, or FIDES program, will be providing a replacement capabilities to many of the Halden reactor capabilities.

Planned experiments under the FIDES framework will

provide insights into accident tolerant fuel design performance, these capabilities for ATF designs foreshadow their potential to support advanced reactor programs as well.

Through participation and leadership in FIDES, the NRC will be able to leverage fuels and materials research conducted around the world and foster international and domestic partners to meet our research needs.

The image you see at the top right is a view of the top of the BR2 test reactor in Belgium. One of our first joint experimental programs under the FIDES framework, and they're called JEEPs, it's called P2M, or Power to Melt and Maneuverability.

That will be a series of two integral in pile tests performed in the pressurized water capsule at the BR2 reactor and it's aimed at reaching incipient fuel melting at the end of a specific long-lasting power transient to assess actual operational margins and overall fuel behavior.

In the U.S., DOE and the Idaho National Laboratory, are sponsoring a JEEP called High-Burn up Experiments in Reactivity Initiated Accidents, or HERA and it's dedicated to the understanding of LWR fuel performance with a high-burn up under reactivity-initiated accidents.

And that's used in transient reactor test facility, or TREAT, which is located at the Idaho National Lab.

Similarly, the NRC International Users Group for Severe Accident Analysis, we call that the CSARP program, radiation protection, which is the RAMP program, and thermal hydraulic analysis, the CAMP program, provide the opportunity to collaborate, exchange knowledge and

build capabilities.

Lastly, on university engagement over $2 million of the FY20 NRC mission related R&D grants support advanced reactor research capabilities, including modeling for heat pipe, microreactors data for molten salt reactors, new approaches to uncertainty analysis, verification and validation work and use of liquid metal data for thermal hydraulic and computational fluid dynamic codes.

I'm very proud of this past year where we created the mission related R&D funding opportunity announcement as part of the integrated university program. We are continuing that approach this year in Fiscal Year '21. In addition to our traditional scholarships, fellowships and faculty development grants.

The results of these grants programs provide not only a pipeline of capable university graduates, but they also provide information that could help inform regulatory and industry activities to support advanced reactors.

With our highly trained staff, modern and adaptable analytical capabilities and extensive external partnerships, Research is well positioned to support advanced reactor licensing.

Next Raj Iyengar will highlight several of our important successes in the materials research areas. Raj.

MR. IYENGAR: Thanks so much, Ray. Good morning, Chairman and the Commissioners.

The fuel selection and qualification for advanced reactor

designs are long-lead and design limiting. Two years ago I appeared in front of you to highlight our multi-pronged approach to prepare the agency for licensing advanced reactors, reactor materials and component integrity.

I'm glad to note that we have been expeditious, yet judicious, in accomplishing our goals. In the next few minutes I expect to convince you that we are continuing to deliver on our commitment.

Next slide please. A few years ago, the staff developed plans to initiate research projects and collaborative efforts to prepare the readiness for materials and components for advanced non-light water reactors.

Our proactive approach has brought early fruits. Staff has made significant progress on technical issues through issuance of reports on molten salt compatibility, high temperature materials and compatibility, graphite performance, and an assessment of American Society of Mechanical Engineers, known as ASME, code related to materials qualification.

Staff engagement with code committees and international workshops have enabled building new capabilities in advanced materials to high temperature applications and supporting the identification of key challenges.

We had conducted a successful and well-attended international workshop on advanced non-light water reactors materials and component integrity in December of 2019. The discussion and presentations led to the event of such activities underway to address the challenges.

Staff is completing an independent assessment of ASME

Section III, Division 5 - Design and Construction Rules for High Temperature Materials. This effort will result in a technical basis document, draft regulatory guide for public comment, paving the way for applicants and vendors to use code qualifying materials.

I'd like to provide an example that underscores staff agility. Recently, a new high temperature alloy, known as Alloy 617, was qualified by ASME marking the first high temperature material to be code qualified in nearly 30 years.

Staff initiated an effort to develop independent technical basis to potentially endorse the code case. The staff has developed computational tools for confirmatory use of high temperature metal components.

This tool will enable efficient licensing reviews and could also be used to verify alternative approaches to materials qualification based on vendor specific designs.

You may notice the mention of a workshop on advanced manufacturing technologies known as AMT in the slide. I'll provide more context later.

Next slide please. As we conduct our research, the staff is continuous exploring leveraging opportunities.

The slide visually captures the extent of our outreach. Staff has engaged proactively to prepare for the adoption of advanced manufacturer technologies, known as AMT, in nuclear application in anticipation of industry applications and licensee submittals.

While the research activities are focused on near-term applications of these components for operating rector, impact of this technology is expected to be more profound for advanced reactors. Recognizing the need to build staff capabilities through hands-on activities, RES has detailed a staff member on a part-time basis to Oak Ridge National Lab to work with a transformation challenge reactor program team.

Staff is also leveraging a small future focused research program on digital trends to better understand the application, digital instrumenting, to aid accelerated qualification of AMT components. We have partnered with Idaho National Lab and Oakridge National Lab to execute various aspects of this project.

Over the last three years, we have built strong international partnerships that facilitated significant information exchanges and benefitted our knowledge, data and international experience.

I'd like to briefly mention three such interactions. Our colleagues in the Office of Nuclear Regulation, United Kingdom, have been extremely forthcoming in sharing their research, data and operation experience on crafting components.

We are furthering our collaboration to include other topics, such as advanced manufacturing and failure assessment of high temperature components. We both have benefitted from the information from Japan Atomic Energy Agency on high temperature materials, operational experience with sodium fast reactors, and thermal related programs.

More recently, we have initiated an engagement with the

Research Center Rez in Czech Republic on molten salt electro-chemistry and materials compatibility.

Next slide please. So, where are we heading? The next phase of our support will involve activities to prepare the staff to address technology specific and material specific aspects, including staff's technical assessment and potential endorsement of ASME, Section 11, Division 2 reliability and integrity management.

Technical issues related to molten salt environment and application of application of digital engineering and advanced sensors to reduce uncertainties and risk.

In so doing, we will expand our leverage to external collaboration for data acquisition and information gathering to aid staff's independent assessments incorporating applicable risk insights.

Before I turn over to Marilyn, I want to express my gratitude and appreciation to the small staff team who have, over the last three years, applied the passion to learn new topics, the energy to seek solution through leverage and their commitment to move the dial dispute limited resources.

Indeed, I'm quite honored and privileged to be part of the team and the great NRC culture. Thank you so much.

Next speaker will be Marilyn Diaz.

MS. MALDONADO: Thanks, Raj. Good morning, Chairman and Commissioners. Thank you for the opportunity to inform you on staff efforts on advanced reactor fuels and its regulatory preparedness for the licensing of fuel fabrication and transportation.

The division of fuel management in NMSS has the lead for planning for and conducting regulatory reviews of advanced reactors which focus on fuel cycles, transportation and storage activities.

Next slide please. We are making progress with license fuel fabrication and certified transportation packages of advanced reactor fuels. We have completed a few transportation package certifications for advanced reactor fuel in limited quantities, including a transportation package that can transport TRISO particles.

We have also an ongoing review of Centrus license amendment to support the development of high-assay low-enriched uranium, also known as HALEU, for DOE's HALEU demonstration program and we are on track to complete it this year.

We have experienced licensing fuel fabrication and certifying of transportation packages of higher uranium enrichments and advanced fuels. We're leveraging our current experience to ensure the safe fabrication and transportation of advanced rector fuels.

This experience also ensures that our reviews will be risk-informed and efficient for the near-term advanced reactors concepts. For example, we recently reviewed and approved a package to allow transportation of accident-tolerant fuel rods that reach up to seven percent.

We risk-informed this review by using engineering judgement to conclude that there was sufficient margin in the criticality analysis to compensate for the lack of critical experiments in the enrichment range for benchmarking.

Next slide please. We are proactively working on our regulatory readiness for the front and back end of the nuclear fuel cycle to enable the safe use of this advanced fuels to support industry timeline for deployment of advanced reactors.

We're currently monitoring the DOE activities and budget allocations, industry's plan and participating in external forums to maintain external awareness and be prepared for any shifts in landscape plans or schedules.

Staff has examined the current regulatory framework and with the information we have today on advanced reactor fuels, we have concluded that current regulations are flexible enough to accommodate the advanced reactor fuel cycle.

To date, no changes to our regulatory framework for fuel cycles facilities, storage and transportation, which includes 10 CFR Part 70, 71 and 72, are needed to support the near-term advanced reactor concepts, such as designs for solid fuel.

The regulations are performance-based and technology inclusive, which are expected to sufficiently comprehensive for risk-informed licensing of advanced reactor fuel processing operations, transportation and storage.

We continue to assess our regulatory infrastructure to identify any challenges and/or data needs for longer term advanced reactor fuel concepts, such as the non-solid fuel forms to ensure our readiness.

Potential challenges include, use of special nuclear material

of moderate strategic significance, also known as Category II quantity of materials, which in this case are those with higher enrichments ranging from ten percent to 20 percent. This will impact the material control and accounting, physical security and risk profiles that may introduce being hazards.

On the transportation area, a potential challenge includes criticality benchmarks that are using the verification of criticality computer codes. There is currently a lack of this benchmark for the HALEU levels.

What this means is that without this benchmark additional conservatism will need to be added and may result in smaller packages for transporting material.

We're addressing these challenges by conducting technical evaluations associated with advanced reactor fuels. Additionally, we are identifying any information needs and assessing necessary updates to our guidance so that we can address these challenges in a timeline that supports advanced reactor licensing.

We're ensuring our readiness with the development of an advanced reactor fuel strategy plan to ensure that we complete the research needed to obtain the information to support the industry timelines.

The information gathered by our technical reports, research and readiness activities are intended to add to a library of information we already have so that we can be efficient in our reviews and update our guidance if necessary.

We're working closely with the Office of Nuclear Regulatory

Research to ensure we have information necessary to ensure our review of transport packages is efficient, focusing on safety.

We're also coordinating with the NRC across offices. For example, the NRC expects some of the research efforts related to accident and tolerate fuels with higher enrichments, specifically with respect to criticality safety, to benefit the licensing and certification of advanced reactor fuels.

We're also using the strategic workforce planning to focus on developing our people with the goal of ensuring that our workforce is fully equipped with knowledge and skills needed to support the workload.

Next slide please. We are proactively engaging with the industry and stakeholders. We're conducting pre-application meetings to enable staff and applicants to facilitate a more effective and efficient licensing certification process.

For example, we're involved in pre-application meetings with X-energy for a future submittal of the TRISO fuel fabrication facility and have also conducted several pre-application meetings with transportation vendors on advanced reactor fuel transportation package design.

We continuously and actively participate in periodic stakeholder public meetings, workshops and conference. For example, our staff has presented in several advanced reactor stakeholder meetings to inform the public our progress in our readiness activities with the goal of providing regulatory clarity and transparency.

We're engaging industry via letters to communicate the

timelines for necessarily regulatory activities to support fuel fabrication and transports of advanced reactor fuels. We're also engaging our federal and international partners to leverage information and best practices.

We periodically meet with DOE on fuel cycle, transportation and storage. We're also actively engaged with international communities and groups.

Thank you for your time. And now I will turn it over to Michelle Hayes. Thank you.

MS. HAYES: Thank you, Marilyn. Good morning, Chairman and Commissioners.

I'm excited to have this opportunity to share how the NRR staff are using research and international activities to make advanced reactor reviews more safety focus and efficient. As Rob mentioned, we have engaged in these reviews for a few years now.

We've completed several evaluations and have many others underway, including the first combined license application for a non-light water reactor, the Oklo Aurora.

Slide 24 please. Because the landscape for advanced reactor technologies changes so frequently, we are continuously engaging with Ray's team and research to reevaluate priorities, to ensure we have the analytical capabilities available for each specific technology and time to support the ongoing and upcoming reviews. And we've been successful to date.

Ray mentioned the concept of a reference plant model to

exercise technology specific analytical tools. This proactive approach has provided staff with insights early in their reviews.

For example, results from the microreactor plant model alerted staff to safety significant features of the Oklo Aurora design. Staff also used a technical report on nuclear data uncertainty from a Department of Energy Laboratory to give confidence other features of this design were not as important.

This demonstrates how staff are seeking information from multiple sources to inform a graded review approach that focuses on the safety significant items.

We appreciate the analytical codes and models being developed by RES. We plan to use them to perform limited confirmatory analysis focused on the safety case, such as novel features with less operating experience, areas with small safety margins or areas where sensitivity studies would provide an efficient means to understand the important phenomena.

As Ray and Raj mentioned, we plan to issue draft regulatory guides endorsing three high priority consensus codes and standards by the end of this calendar year. One of these is the non-light water reactor probabilistic risk assessment standards.

For vendors using the licensing modernization project, the acceptability of the probabilistic risk assessment takes on added significance because its results are used to establish a safety case.

Our regulatory guide endorsing this standard will provide the

industry with clear expectations for acceptability at the different phases of design and construction. This regulatory guide will also endorse peer review guidance developed by the Nuclear Energy Institute, which will make our reviews more efficient because staff can focus on the areas identified during the peer review.

We continue to engage internally and with stakeholders to evaluate options for vendors not using the licensing modernization project.

We are aware of advanced reactor designers who are considering the use of additively manufactured components. The advanced manufacturing action plan will ensure we're prepared to review these applications when they arrive.

Slide 25 please. The NRC is actively engaged with international communities to develop common regulatory positions and guidance and to facilitate the exchange of information on the safety and regulation of advanced reactors.

As part of the International Atomic Energy Agency, small modular reactor regulators forum, we align with international regulators on important topics, such as fundamental safety functions and defense-in-depth.

The position papers produced by this forum, and exposure to other regulatory approaches, allows us to leverage international experience for developing NRC regulations and guidance.

We recently collaborated with the Nuclear Energy Agency's working group on the safety of advanced reactor on guidance for fuel qualification. And as a result, the guidance documents issued by the working

group and the NRC are very similar.

This allowed us to take advantage of international expertise to inform our product and harmonization with the international community will help vendors considering licensing in more than one country.

We expect the same benefits from ongoing collaborations on analytical codes and methods and recently initiated project on materials qualification.

Building off what Rob shared regarding our work with the Canadian Nuclear Safety Commission, within the past six months we have established the structure and format for joint products, approved five work plans and are nearing completion on the first two projects; a joint review of the construction code X-energy proposed for the Xe-100 reactor pressure vessel and documentation of areas of commonality and differences between our licensing modernization project and the Canadian guidance.

Slide 26 please. As evidence by today's diverse speakers, our ability to execute our vision is the result of a coordinated agency-wide effort where staff are working across offices towards a common goal.

I'd like to thank the staff I work with in the advanced reactor program for their dedication, adaptability and innovation. In addition to developing the technical skills necessary to resolve policy issues, develop guidance and perform reviews in this very different world of advanced reactors, I've seen them embrace the challenge to become a modern risk-informed regulator.

They are focusing on safety significant items, streamlining

processes and products, and striving to make the safe use of advanced reactor technology possible.

The photos on that last slide reflect the sixth implementation action plans that Rob shared in an earlier slide. The progress made to date in each area has positioned us to perform today's licensing reviews and will continue to execute the plan to prepare for the diverse technologies expected in the future, and to make our upcoming reviews even more efficient.

Thank you for time. Now I'll turn it back to Margie for closing remarks.

MS. DOANE: Thank you, Michelle. And in conclusion, I want to add my thanks to the staff across all of the offices in the advanced reactor program.

And I'd also like to thank the staff that helped us prepare for this meeting today. They put in countless hours.

And with that, I turn it back over to you, Chairman, for questions from the Commission.

CHAIRMAN HANSON: Thank you, Margie. And thanks to the staff for that presentation. And we'll start the questions this morning with Commissioner Baran.

COMMISSIONER BARAN: Well thank you all for your presentations and your work. I want to start by asking about the Part 53 rulemaking, as Margie predicted, I think. Because that will establish the overall regulatory framework for advanced reactors.

On the first panel I ask about PRAs and whether the rules

should offer deterministic avenues for vendors to demonstrate the safety of their designs. Rob, what's the staff's current thinking about whether the rule should require an applicant to have a PRA and whether the PRA should be reviewed by NRC staff during licensing?

MR. TAYLOR: Thank you, Commissioner, for the question. Currently the preliminary rule language does include a requirement for applicants to have a PRA. However, as I indicated, we're at an iterative process for revising that language.

In our most recent iteration we've attempted to provide some additional flexibility to allow applicants to use other generally accepted risk-informed approaches. Things like the IAEA SSR standard, and other generally accepted risk-informed approaches.

So, from that perspective, I think it's been discussed that we kind of started with building Part 53 off of an approach that attempted to maintain consistency with prior PRA decisions by the agency, such as the requirements in Part 52 and the PRA policy statements.

But we're seeing stakeholders express some interest to have some even more flexibility and diversity and we're considering that as we revise and consider the revisions to the rulemaking.

We believe that the PRA provides one potential opportunity to scope the rule and help with the development of the design and identify what's truly risk-significant in a technology inclusive kind of way.

So we see the PRA or our graded risk-informed approaches being valuable in that sense. So we want to make sure that we, if we go with

alternative approaches we can accomplish those goals that we talked about out of the advanced reactor policy statements and still be successful with the rule at the end of the day.

So I think we're still dialoging on it. We certainly haven't made a decision and we've also stood up a group to look at developing a graded PRA approach that might be useful and applied in the role. So hopefully that answers your question, Commissioner.

COMMISSIONER BARAN: Yes, that's very helpful, Rob, thanks. The current regulatory framework has a long list of deterministic requirements applicable to light-water reactors.

I didn't envision the new framework trying to create equivalent lists of deterministic requirements for other technologies, I was imaging something more technology neutral. What are the staff's current thoughts about that?

Are we going to see a lot of detailed technology specific guidance with the rule?

MR. TAYLOR: I'll start with that, Commissioner. Our goal is a technology neutral framework. And so that means, both within the regulations and our guidance.

I think, as I mentioned the diversity, and you heard the first panel talk about it a lot, the diversity of the technologies that we're going to see will create challenges if we try to build guidance for every single possible design. So you are seeing things like, in the advanced reactor content of applications guidance that we're building.

We trying to make sure that the scope is with regards to how we're going to focus on the most safety-significant and risk-significant aspects of those designs and ensure that the level of detail and the content that comes into us is commensurate with that risk and safety significance.

So, long story short, I think the goal is to stay as technology inclusive as possible. If we identify a need or stakeholders identify a need I think we'll adapt and adjust and consider building technology specific where we need it. But it wouldn't be our first desire or priority I think.

COMMISSIONER BARAN: Okay. On the first panel Ed Lyman raised the question of whether NRC will require prototype testing of the designs receiving financial support from DOE. He recommended that NRC define the additional design features needed for the prototypes.

What is the staff's current thinking on whether prototype testing will be required?

MR. TAYLOR: That's a great question. I wish I had a crystal ball, because I think it's still a little too early to tell at this point. Because the venders are still developing their designs and engaging with us in pre-application activities.

Dr. Lyman was very good in pointing out that in 2017 we put out a regulatory review roadmap document and it has an enclosure and two great appendices that specifically talk to this subject with regards to how essential applicants can consider developing their testing and analytical programs to make the case under the 10 CFR 50.43(e) requirements which allows two different approaches, one of which is a prototype approach.

But the other is one to demonstrate, through testing and analysis, that they have the sufficient data.

You also heard it in the first panel, one of important things is making sure that the data and analyses are sufficient to support the conclusions being drawn, so taking the insight from prior lab work, and NRC licensed facilities, and then demonstrating how that data and analysis can be applied to these new designs will be a critical focus area as we make our independent assessment and determine whether a prototype facility is needed.

I think they need to make the argument to us and the justification to us as to why they have that sufficient data, and then our job is to assess it independently and reach a conclusion. So long story short, I think it's just a little early to make that conclusion at this point.

COMMISSIONER BARAN: And do you have a sense, I mean, and I understand it'd be kind of case-specific, but do you have a sense, is that a demonstration you would expect that would be made in the application, or it would be, you know, during pre-application discussions? How far along would someone be before they needed to, where they would find out NRC's determination about whether they needed a prototype?

MR. TAYLOR: So I think, it would certainly be, we put out a draft white paper last year on what we considered an effective strategy for pre-application engagement and it highlights a number of areas that are critical to supporting the overall safety and licensing basis for the facility that will be submitted to us.

So I think if we -- and we've heard a number of the vendors indicate their appreciation for that and their intent to follow it. So I think it's, my desire would be that it would be a logical outcome from that discussion as we engage in those pre-application activities to assess whether there are any gaps in data and analysis that would make it a challenge for us to make the finding under 50.43(e) that there's sufficient information, and the prototype facility is not needed. So to me, it's a critical item within the pre-application activities.

COMMISSIONER BARAN: Okay. One of the big policy questions around advanced reactors is what siting limitations should apply. The NRC staff has recommended changing the guidance and interpretation of the regulation to significantly scale back siting restrictions for advanced reactors.

Under the suggested interpretation, reactor designs deemed sufficiently safe on paper could be sited within a town of 25,000 people and right next to a large city.

For reactor designs that have not been deployed before, and have no operating experience, does the staff believe that this would be a sufficiently cautious approach to protecting the public? And how would it be consistent with the regulatory requirement that reactor sites should be located away from very densely populated centers?

MR. TAYLOR: Thanks for that question, Commissioner. We gave that a lot of thought as we developed that paper. I think we submitted it to the Commission last year. And it included the four options as

considered the spectrum of possibilities for how we could do this.

And we ultimately did recommend an option that included updates to our guidance. And we recognized that that was an important policy consideration for the very reason you mentioned at the end with regards to prior Commission policy statements on this fact.

So when we think about siting, I think the staff thinks about it holistically in the case of protecting public health and safety both from the safety and the siting aspects of the design. So I don't think you can go forward with a decision on the acceptability of the site without a good and comprehensive understanding of the safety basis for that facility which would have to be demonstrated as part of the licensing application.

So in my mind, while we were proposing to update the guidance and provide or allow for more flexibility, ultimately you shouldn't make the decision on whether the site is acceptable until you've also included the prospectus regarding the safety of the design. So I think those two are inextricably linked in our mission to protect public health and safety.

COMMISSIONER BARAN: Do you see that as a change though from how things have been done in the past? You know, I sense the history of this is that traditionally it's been the opposite. That one of the key principles of siting was that it was an independent defense in depth measure separate from, independent of design.

And kind of what you articulated is really the opposite of that which is it's totally enmeshed in the design review. How do you think about that?

MR. TAYLOR: It's a great question, Commissioner. I think we have historically provided layers of defense in depth in our licensing approaches to technologies. And I think that we can continue to maintain that if the Commission determines that's the appropriate way to go.

But I also think that making sure that we take a holistic perspective on the safety of these designs in the facilities is an opportunity to be somewhat transformative in how we think about it. We still want to have the appropriate defense in depth in the barriers to protection of public health and safety.

But I think we can look at how we accomplish that in a variety of mechanisms for these advanced reactor designs, if they achieve the safety goals that they're proposing that they could achieve. So I think it's an important factor as we consider the designs and the overall safety in the protection of public health and safety.

COMMISSIONER BARAN: Well, I appreciate the staff's thoughtful paper on this. It gives us a lot to think about. I also appreciate the value of a risk-informed approach.

When I think about it holistically, I worry that pairing minimal siting restrictions with no offsite emergency planning zones for a first-of-a-kind reactor wouldn't be prudent. That's my concern. But thank you for your thoughts on that. Thanks.

MR. TAYLOR: Understood, thank you.

CHAIRMAN HANSON: Thank you, Commissioner Baran. Commissioner Caputo?

COMMISSIONER CAPUTO: Thank you. And my thanks to the staff for their hard work in preparing their presentations today, both those who gave remarks and those who supported the development. It's a voluminous amount of information to cover in one meeting, and I really appreciate the hard work that went into that.

I'm reflecting on some of the comments that were made in the earlier panel and just how we heard criticism from several of the speakers about the rush to develop Part 53 and how that may result in a rule that has a rigid over-reliance on PRA with inadequate flexibility and that this may result in a rule that may be unworkable and unused by innovative designs.

I'd like to point out, however, that the staff is currently reviewing our first application for advanced reactor. And the agency spent nine months deciding which aspects of our regulations would apply and govern the review. So I would just suggest that the practical ramification of this is the development of an application-specific regulatory framework, de facto.

Given the expectation of 13 incoming applications, how tenable is it to recreate a technology-specific, application-specific regulatory framework? And doesn't that situation create a sense of urgency to finish Part 53 and to get it right?

Rob?

MR. TAYLOR: Sure, Commissioner. Thank you for the question. I think it is a great question. And I listened intently as it was asked and discussed during the first panel.

I reflect, and I keep a copy of the SRM from the Commission that, in my mind, was clear about the importance of both moving expeditiously to build Part 53 to provide the flexibility and to minimize the need for exemptions and the very things you talked about in your question.

So Part 53 and the importance of developing Part 53 is critical, in my mind, to enabling technologies in the deployment of advanced reactors. But it's equally critical to get it right. And I think that's a tremendous balancing opportunity and effort that we have underway.

So that's why we're doing the extensive outreach, and we're trying to apply the novel approach of releasing the preliminary language as we go and soliciting the feedback from the stakeholders.

So our goal is to try to accomplish both of those things. And I know it's going to be a challenge. We highlighted what we thought those challenges were as part of our paper that we sent to the Commission in November of last year.

COMMISSIONER CAPUTO: So you mentioned earlier in response to Commission Baran, you talked a little bit about PRA and creating some perhaps more flexible options. Could you just discuss a little bit more, in perhaps other areas of development, how you're balancing the need for predictability, clarity, stability, with the need for flexibility in a technology-neutral regulation?

MR. TAYLOR: Commissioner, I just want to make sure I understand the question. Is it Part 53-specific or is it ---

COMMISSIONER CAPUTO: Yes.

MR. TAYLOR: -- is it a more generic ---

COMMISSIONER CAPUTO: Within Part 53.

MR. TAYLOR: Ah, within Part 53, okay. So Part 53, and I think one of the key elements as we try to develop and do this balance that we're talking about, is how to accomplish a truly performance-based regulation, one that acknowledges what the outcome will need to be and then provides the flexibility on how to accomplish those outcomes.

And as you can imagine, there could be multiple ways to be successful in doing that. And I think the dialogue we're having, and I still think for early in the process for developing this rule, is highlighting that different stakeholders have different perspectives.

I mean, you heard it from the first panel that there's a lot of stakeholder perspective in how to strike that right balance relative to it.

And one of the things we want to make sure that we do accomplish, well, two things we want to make sure that we accomplish, we think it's critical out of the advanced reactor policy statement that we maintain the same level of safety for the advanced reactors that we do for the existing fleet of light-water reactors. That was critical. So our goal is to maintain that bar in the same place relative to the technology.

And then the second is that we allow for, if the designs demonstrate their enhanced safety margins, that will allow for increased operational flexibility. And in fact, at the public meeting last week, we rolled out a white paper that talks about an approach to potentially supporting things like autonomous operations in advanced reactors.

And we think that's critical that the framework would enable that kind of capability. And one of the keys is how do you demonstrate the safety margins that allow you to take and use those operational flexibilities as we go forward. So it's a significant challenge and it's something I think that the staff is working aggressively on.

COMMISSIONER CAPUTO: Okay. So I'm going to have you develop a little more, a couple of things that you mentioned in there. So this iterative process, you know, how beneficial has that been?

I know there can be some tension between perhaps stakeholders having some criticisms of the portions they've seen which may be attributed to the fact that there are portions that related to it that they may not have had the benefit of reviewing yet.

So how efficient and effective is this iterative process in sort of trying to develop concepts, and ideas, and approaches concurrently, even though not all portions are available at once?

MR. TAYLOR: And so that's a really good question, Commissioner. I think as you try anything as novel as doing this, and we have released preliminary language and other rules like we did it on the advanced reactor physical security rulemaking, you can find that it can be very beneficial.

Because it allows a focusing of what are the critical issues, where are the potential gaps or misunderstandings between us and stakeholders. And it allows us to hone in and focus on those dialogues, that dialogue to get to a more tangible, hopefully, outcome and understanding of

each other.

That said, it does create a challenge to confront reality as you put out iterative language trying to make sure you're building all the pieces together. And we talked about this last week. It's difficult as we're moving aggressively on this rulemaking.

And we can certainly understand why some stakeholders want to see all the pieces put together, to make sure that they have the whole picture of the rulemaking. And we're working as quickly as we can to build all the subparts and to get them released so that we can do that.

And that's one the reasons we committed that we would leave the language open, especially on important pieces like Subparts B and C. Because we know we'll have to go back as we build those subsequent pieces.

And we may find that some of the things we thought we needed to do in Subparts B and C, we don't actually need to do. And we can remove those pieces or move them to other sections of the rule. So that's why we recognize that we can't lock in on any particular aspect. And we need to put all the pieces together and continue to have the dialogue. It'll help us build a better rule at the end of the day.

I think we should do a lessons learned at the end of this and ask the question is this the right format and structure for rulemaking going forward. But right now, I think it's the best approach we can have to have the dialogue we need with the stakeholders.

COMMISSIONER CAPUTO: Another point that you

mentioned earlier is that you are seeking to apply the same level of safety requirements as existing reactors, yet the NRC's been criticized for considering a broad weakening of regulatory standards for non-light water reactors.

I think one dynamic here that gives me a little bit of pause is certainly between where we stand now and the nature of how our reviews over the next several years will be governed by deciding what portions of our regulatory framework to apply to these reviews.

And with each design potentially being different with different applicability, we certainly open ourselves to criticism that we are perhaps exempting certain designs from safety standards.

How, through the nature of, you know, the review work as you expect it over the next several years, how you both counter this concern of weakening our regulatory standards, and how do you communicate the nature of how you're setting the regulatory standards and ensuring that high level of safety?

MR. TAYLOR: Thank you for that question. I think it is a significant challenge. One thing I'll go back to, and we've had a lot of dialogue with our stakeholders with regards to the approach to the applicability of the regulations in Part 50 and 52 to the advanced reactor technologies and the designs, and we put out a white paper that we received comments back on. And we've continued to iterate, and take those comments, and add value to it.

And one of the things we're thinking about is putting a flow chart in that paper that'll help these new technologies move through it. And

that should help provide transparency to both those entities who are going to apply to us as well as to the pubic who's following our activities.

Because I can tell you that there's no -- the dedication of the staff to our safety mission is phenomenal, and to our NRC values.

So there is, I understand those who may think or see that a change to our requirements is a perception of weakening them. I see the opposite. I see that it's a commitment to maintaining our values and our commitment to our mission, and just finding a different way to accomplish that same outcome.

So the key is to provide opportunities to do that transparently, so that the stakeholders can follow what we're doing and that we listen to them and respond to them if they think that we are relaxing or weakening our requirements.

COMMISSIONER CAPUTO: I agree with you in the level of confidence that we place in the agency staff, both in terms of their commitment and dedication but also in their level of expertise. So I think really communication here is probably a key effort. And so your focus on transparency, I think, is a good one. Thank you for that.

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

COMMISSIONER WRIGHT: Thank you, Mr. Chairman.

So, Rob, first and foremost, I want to thank you and your staff for your efforts in this area. This has been really enlightening. And I also want to give you the opportunity to comment or maybe even respond to

some of the feedback more than you have already.

I understand there's been a lot of dialogue about the safety objectives in Part 53 and the staff's considering a tiered approach. I believe it's been referred to as adequate protection and extra-adequate protection.

So given that our mission and findings are tied to reasonable assurance of adequate protection, can you help me better understand how the second tier or extra-adequate term is consistent with the findings we're going to have to make?

MR. TAYLOR: Thank you, Commissioner Wright, for the question. I don't think -- I would start with this, the term extra-adequate protection comes from a letter that was submitted to us by the Nuclear Energy Institute. So it's not a term that the staff has been using within the context of building Part 53.

COMMISSIONER WRIGHT: Very good.

MR. TAYLOR: But that's initial thinking when you say this is -- we're trying to build this rulemaking that raises the performance-based aspects of the rule and what needs to be submitted to us to make our regulatory findings.

So as we think about what we have built in Part 50 and 52, we think about the idea that we don't want everything to just fall into one of two buckets, safety related or non-safety related. We've recognized over the years that there's value to having that spectrum of things can be classified and maintained by the licensees within their own programs. Think about the maintenance rule, kind of thing.

So what the staff's approach with the two tiers was to do was to try to give that flexibility to do that and to have those capabilities for the management of those materials.

We still think all of it falls within the adequate protection realm, and we're still having dialogue with the stakeholders to see if our thought process and our logic stands up and is understandable to stakeholders.

And so we're open and amenable to the flexibility and the approach for how the two tier structure works and what will need to be within those two tiers. So I think we're a long way from a decision on that.

And it's going to be really dependent on how it interfaces with the other parts of the rule, like the operations piece that I was talking about a little bit earlier. I hope that helps to answering our question.

COMMISSIONER WRIGHT: It does, thank you so much.

And you heard me ask the question, and I think Mr. Sell responded to it, talking about the flexibility part and that some people were out there thinking that the, to follow-up on Commissioner Caputo's questioning too, that it was just too big. And people may not use it, because there weren't enough flexibilities built in, or a graded approach, or something like that.

And I think I heard you really acknowledge that you've heard that and that you're really trying to incorporate those types of flexibilities within the rule, although we're very early. Am I correct, did I hear you correctly in that?

MR. TAYLOR: You absolutely did, Commissioner. I do

want to say this. I do think that Part 53 has -- at least the preliminary language is crafted. It's substantially more flexible than Part 50 and 52. I think we've taken a substantial step towards a performance-based regulation.

Does that mean we should stop and declare victory? Absolutely not, we should continue to have the dialogue and ask if there's more flexibility that could be incorporated into it. But you're not going to find very prescriptive requirements on fuel cladding performance or containment leak rate testing right now in Part 53. So you're going to find a much more performance-based type of structure.

And then we are -- what I'm appreciative of is the discussion we're having is how to accomplish those pieces. And I think that's the right conversation. And I think Steve Kuczynski kind of hit on it during his session. Those are the kind of conversations we should be having.

And these are difficult issues that we need to work through. And we need to challenge ourselves to do it in a timely and effective manner. But we also have to make sure we do it right. So I think the questions in the first panel are really important and significant on the point of trying to drive to resolution but also be mindful of getting it right at the end of the day.

COMMISSIONER WRIGHT: All right, thank you so much. I really appreciate your openness and the way you're sharing with us today. This has been really enlightening. So thank you so much.

And I'm going to switch gears for a minute. I want to go to Raj for a second. I understand that Advanced Manufacturing Technologies, or AMT, is used as an umbrella term to cover a broad range of novel and non-

standardized manufacturing methods and materials that aren't traditionally used in the US nuclear industry.

Could you give me a few examples of how potential applicants propose to use AMT in advanced reactors?

MR. IYENGAR: Yes, the staff is working on the agency action plan on the advanced manufacturing technology applications. As part of the effort, it's a collaborative with the Office of Research and NRR.

That effort, we are making assessments of the state of technology for specific technologies that will be of interest to the licensees in terms of application. Based on the assessment reports, the staff is developing technical positions which will be used for inspection guidance for these technologies. We have completed one such effort and we are embarking on other technologies as we go. And our efforts are dependent on largely what the industry is contemplating.

In addition to that, we've also developed state of the -- technology assessment supports for radius views of modeling and simulation to augment some of the data needs that we might have, as well as pre-service inspection which is fairly important for the use of these advanced technologies.

We do understand that, in terms of, specific to nuclear reactors, nuclear applications, we need to get more information on the radiation damage. And that's going to be, that's going to have to wait until we get more experience and more data on all of those things.

But this is essentially what the staff is doing. The staff has followed many, two years ago actually, when I came and talked to the

Commission, we even got actively embarked on this project. But since then, I actually made tremendous progress in that effort.

COMMISSIONER WRIGHT: Thank you so much. And, Mr. Chairman, I yield back.

CHAIRMAN HANSON: Thank you, Commissioner Wright.

I just want to start off by acknowledging the outstanding efforts of the staff in supporting the advanced reactor program. I think the conversation that we've had at the Commission this morning, and particularly with the first panel, I think really highlights the significant challenges and the complexity associated with this effort, and the multiple, the areas of balance and consideration kind of along multiple axes that the staff is having to consider.

While we're trying to accommodate, you know, really what is a pretty dynamic and evolving landscape out there in the world in terms of what might come to the Commission, all while, I think, as Rob really eloquently noted, the ongoing really strong commitment by the staff to serve the public and ensure the safety of the issues before us, as well as just the flexibility not only in developing this new Part 53 but also for applicants that are coming in and wanting to use Part 50 or Part 52.

And I want to recognize the significant challenge, and I want to really applaud the tremendous amount of effort and creative thinking that the staff has put in so far.

So with that, I want to recognize -- Rob has gotten a lot of love this morning. And don't get me wrong, I love Rob too. But I'm going to

spend a little time with Marilyn, ha, ha, ha, because I am interested. And I wanted to revisit this question I had earlier, for the earlier panel, about data gaps in HALEU.

And I think it was, Marilyn, in your presentation, you had mentioned a lack of benchmarks for high-assay low-enriched uranium. And, you know, without some of these benchmarks, additional conservatism might be needed in terms of handling this fuel, storing this fuel, transporting that fuel.

And I'm just wondering if you could say a little bit more about that and how the staff Is working to address those, either with the National Labs or with vendors, or others?

MS. MALDONADO: Sure. I'll say that, for fuel cycle, transportation and storage, I would pull those data needed for code validation that are primarily focused on criticality safety. This is, like I said during my presentation, this is due to the fact that fuel-critical experiments used for code validations are for the less than five percent enrichment, with relatively few in the five to 20 percent enrichment range of interest for advanced reactor fuels.

I'll say that NMSS has the ongoing effort to assess and strengthen the modeling tools for advanced fuels in advance of their anticipated introduction. For example, we have made significant --

(Audio interference.)

MS. MALDONADO: Our capabilities in criticality and shielding modeling for near term ATF for light water reactors to allow us to effectively evaluate anticipated ATF licensing actions with higher enrichment as well. We're also taking that same approach to ensure that we're similarly

well positioned to evaluate advanced reactor fuels.

I'll also note that we are working with DOE in the GAIN initiative, that they have also ongoing efforts to evaluate those higher increased enrichment benchmarking studies for the uranium hexafluoride with, again, above the five percent enrichment.

So I think we're getting there. We're trying to address the data needs. I think the industry and DOE has -- it's also engaged in getting those benchmark studies. And we have come up with certain paths forward as to how to license those and regulate those.

We have one of the proposed packets to use sensitivity and uncertainty analysis techniques to demonstrate that some of the lower enriched critical experiments are applicable to those with higher. So we're working through it. And we see that we will be able to address those.

CHAIRMAN HANSON: That's great, thank you very much. I mean, I could ask 100 questions about this topic alone and size of transportation packages and certificates of compliance, and a whole bunch of things. But I won't bore my colleagues or the public on that today.

My next question, I think, Marilyn, for you is really going to be about how we're thinking about safeguards and security, and not just exclusively for you, Marilyn, but maybe also for Michelle, about how we're thinking about safeguards and security integrated into some of these designs.

And in particular, I think I've been struck by what I perceive, and this is part of my question, about kind of the material accounting, and control issues associated with, like, liquid fuel type designs and how that's

being accounted for in our design reviews and our regulatory framework.

MS. MALDONADO: Michelle, I can start, and if you have something to add, you can do it after.

What I'll say is, as you may know, the movement of special nuclear material in some advanced reactor designs can differ significantly from existing light water reactors in that the SNM contained in discrete items like fuel assemblies, and refueling, and removal of spent fuel can occur continuously during operations rather than a discrete outage period.

So MC&A requirements for existing reactors take into account the discrete nature of the fuel in the refueling process. SNM, in some of the advanced reactor designs, if you know that they're in liquid form, it's in some ways more, like, at fuel cycle facilities where much of the SNM is considered in process and can be controlled and tracked as such.

The existing, we believe that the existing MC&A regulations for this type of facility have been successful applied at fuel cycle facilities that use these type of processes. And at this point, we expect that the performance-based regulations in Part 74 can encompass the range of designs currently anticipated for advanced reactors.

So staff is pursuing technical studies to confirm this approach. We have been involved in technical studies. DOE is currently sponsoring other technical studies for this and the advanced reactor designs.

For the molten salt designs with the salt fuel, those are the ones that may represent the most distinct challenges for MC&A. But those are being considered in some of the ongoing studies that I mentioned in

planning further work in the future in the next fiscal year, if needed.

CHAIRMAN HANSON: All right.

MS. MALDONADO: Thanks.

CHAIRMAN HANSON: Thank you. Michelle?

MS. HAYES: I don't have a whole lot to add, just that we're aware and we're working on the same studies and working with labs on how best to incorporate that.

CHAIRMAN HANSON: Okay. All right, great. Thank you.

With just a couple minutes to go, I think we'll wrap it up there. I want to thank everyone this morning. I want to thank the public for attending, our staff panelists, our external panelists, thank you especially to SECY for supporting a hybrid meeting.

Obviously all of the Commissioners are here in the room in One White Flint in Rockville. But we've had all of our panelists join us remotely and with very few, if any, technical glitches. And I want to thank the efforts of our secretary, Annette Vietti-Cook, Wes Held, Sergio, and others, for supporting us this morning. And with that, we're adjourned.

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