UNITED STATES

NUCLEAR REGULATORY COMMISSION

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BRIEFING ON ADVANCED REACTORS

(PUBLIC MEETING)

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TUESDAY,

APRIL 24, 2018

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ROCKVILLE, MARYLAND

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The Commission met in the Commissioners' Hearing Room at the Nuclear Regulatory Commission, One White Flint North, 11555 Rockville Pike, at 9:00 a.m., Kristine L. Svinicki, Chairman, presiding.

COMMISSION MEMBERS:

KRISTINE L. SVINICKI, Chairman

JEFF BARAN, Commissioner

STEPHEN G. BURNS, Commissioner

ALSO PRESENT:

ANNETTE VIETTI-COOK, Secretary of the Commission

MARGARET DOANE, General Counsel

NRC STAFF:

VICTOR McCREE, Executive Director for Operations

STEPHEN BAJOREK, Office of Nuclear Reactor Research

FRED BROWN, Office of New Reactors

MICHAEL LAYTON, Office of Nuclear Material Safety and Safeguards

JOHN MONNINGER, Office of New Reactors

BRIAN SMITH, Office of Nuclear Material Safety and Safeguards

ALSO PRESENT:

RITA BARANWAL, Idaho National Laboratory

JACOB DeWITTE, Oklo, Inc.

JOHN HERCZEG, US Department of Energy

NICK IRVIN, Southern Company Services

EDWIN LYMAN, Union of Concerned Scientists

FARSHID SHAHROKHI, Framatome, Inc.

P R O C E E D I N G S

9:04 a.m.

CHAIRMAN SVINICKI: Good morning, everyone. The Commission convenes this morning in this Public Meeting to hear an update regarding what is a very dynamic field of activity right now, at least in my assessment.

And that is the development of the broad panoply of what are termed advanced reactors, so our new reactor technologies.

And of course, the NRC's interest is in understanding this dynamism and what is happening in the larger world, but also then comparing and contrasting the necessary regulatory readiness and preparedness activities that we would need to undertake upon a receipt of one of these new designs for review.

And I think from my assessment, this has some parallels with a meeting that the Commission conducted earlier this month on the development of both accident tolerant fuels and just broadly the qualification of new fuels.

So, I think we're continuing a focus this months on regulatory preparedness for technology, innovation, and development. But we will have two panels this morning, first of which is a number of external participants. Thank you all for being here.

We will follow that with a brief break and then we will hear from NRC Staff Managers and Experts in this subject matter. Before we begin, do either of my colleagues have any opening comments?

Hearing none, we will now begin with, as I've said, a panel of non-NRC experts that we have invited to be here today.

We will begin with Dr. John Herczeg, who is Deputy Assistant Secretary for Nuclear Technology, Research, and Development at the Department of Energy. John, thank you for being here.

Following him will be Dr. Rita Baranwal -- have I pronounced that correctly? Thank you -- from the Idaho national laboratory, who is the Director of the Gateway for Accelerated Innovation in Nuclear, which is a large Department of Energy initiative.

Following that, we will have Dr. Farshid Shahroki -- is that correct? Thank you -- from Framatome Inc., who is here in his capacity of the Chair of Nuclear Energy Institute High Temperature Gas-Cooled Reactor Technology Working Group.

Following that, we will hear from Dr. Dewitte of Oklo Inc. Again, he's here in his capacity as Chair of the NEI Fast Reactor Working Group, and following that, we will hear from Mr. Nick Irvin, from Southern Company Services, who will present in his capacity, as the NEI Molten Salt Reactor Technology Working Group representative.

And following that, we will hear from Dr. Ed Lyman who is here from the Union of Concerned Scientists.

So, I will simply go from my left and we can move down the table, and after the previous presenter has concluded please begin your preparation. So we begin with Dr. Herczeg.

Please begin, thank you.

DR. HERCZEG: Thank you. Good morning, Commissioner Svinicki, Commissioners, NRC Staff, and the attendees of this meeting.

It is my pleasure and I thank you very much for this opportunity, to give you an overview of the Department of Energy's perspective on advanced reactors, our vision, strategy, and strategy of deployment.

First, however, I would like to stress that the administration, President Trump, is firmly behind the advancement of nuclear energy and nuclear reactors.

In a statement in June 2017, he clearly stated that we need to revive and expand our nuclear energy sector and has ordered a new policy review on nuclear energy.

Secretary Perry is equally committed to the president's goals and has a side area of interest in Small Modular Reactors, one of which is the NuScale reactor. Next slide. Is there a clicker? No clicker, okay.

Our mission is to advance nuclear power as we would normally think as a reliable source that will help maintain the nation's energy supply in environmentally clean and energy security.

We seek to resolve our technical cost, safety, and security issues, and regulatory issues through research, development, and demonstration.

Our focus is on the deployment of advanced nuclear technologies to support the goal of domestic resources for secure energy, reducing greenhouse gases, and enhancing national security.

The priorities are listed on the right-hand side of this slide.

We have recently re-arranged our office to focus on the areas of the existing fleet, the advanced reactor pipeline, which is the focus of this talk today and fuel cycle.

On the arrow below, you could see the timeframe that we're looking at for implementation of this strategy, where we have been working for many years to extend the life of Light Water Reactors.

We have gotten many, it takes 60 years, and we are now working on 80-year extensions. We are working on advanced fuels, primarily accident tolerant fuels for Light Water Reactors and advanced fuels for advanced reactors.

We're working on small modular reactors and hope to deploy them in the mid-2020 to the early 2030s and full-sized reactors in the 2030 to 2035 range. Next slide. There are five areas that we focus on for our R&D pipeline.

The first is Light Water Reactors, these small modular reactors such as NuScale. The second is high-temperature gas reactors and there's two versions of that. One is a prismatic and the other is a pebble bed. Some are helium-cooled, some are molten salt.

Our emphasis in this particular area is working on TRISO fuels, which is applicable to both, and graphite qualifications. I'll speak more on TRISO fuels later.

Liquid-fueled reactors, sometimes called molten salt reactors, are a rebirth from the '60s and we have many of them looking at this technology. There are fast reactors, there are thermal reactors, and there are hybrid designs.

These particular reactors require a significant amount of R&D because of the corrosive properties of molten salt.

Metal-cooled fast reactors, we have two in the overall picture here today, and that's the sodium-cooled and lead-cooled. And lastly, I would like to emphasize micro reactors.

We're looking at several of those at this particular point in time and we think they will be a new area in which we can expand and bridge the gap from today until tomorrow.

Next slide, please. Our focus areas are somewhat repeated here but let me just go through the work in those particular areas. In advanced reactors, advanced Light Water Reactors, we are focusing on technical assistance through the NuScale overall program.

That has been going on for a number of years and it will continue to go. In the advanced reactor technology, fast reactor technology, we look to demonstrate the advanced reactor systems and components that are key to cutting the costs within these particular types of reactors.

We have established a laboratory at Argonne National Laboratory called Met Lab, which will test components such as small pumps, valves, and heat exchangers.

We are looking at advanced materials for fast reactors and those materials are also applicable to other reactor-types.

In the gas reactor area, our focus is on advanced alloys for high temperatures, and graphite material qualifications for high-temperature applications. We have also spent and we have been working on for close to 14 years now TRISO particle fuel.

We've developed that fuel to a very advanced state and we've been testing it and hope to have the complete TRISO fuel particle qualified to your standards by 2022.

In the molten salt area, I've indicated that there's both fast and thermal reactors. We're looking at the properties of the salts within those reactors. There are fluoride, lithium salts, and there are chloride salts and there are mixtures of all salts.

Salt properties are very important to understand, in particular as their application of any degradation they may have, and also how they apply it to corrosion.

The materials, fuels, and technology modeling is also a very important part of this particular area, but we also have to be aware and work diligently for safeguards, safeguard ability, because molten salt reactors generally have fuel, not just circulating within the core but go out of the core. And so in those particular cases, we are working on an impact program to make sure we can monitor fissile content as a function of time.

In cross-cutting areas, we are looking at advanced energy conversion. Super critical $CO_2$ Brayton Cycle, we've been looking at that for a number of years, and recently, we've joined up with the Office of Fossil Fuels to put together a 10-megawatt demonstration, which is being funded at the Southwest Research Laboratories.

Micro-reactors and remote deployment of these is another area of a very strong interest within the Office of Nuclear Energy. In January 2018, the Department issued a funding opportunity announcement to advance these particular technologies.

In that opportunity, we broke up into three areas, one for deployment in the 2026 timeframe to support that work, and second, to work on technology-specific areas for certain areas and licensing.

Next slide, please. To support the licensing qualification of advanced reactors and achieve the goals of the Advanced Reactor

Program, we've embarked on a dense test reactor called the Versatile Test Reactor.

The support from this reactor has been very, very strong. The industry has indicated that they need to be able to test our fuel and materials in order to qualify those materials for a license within the NRC.

We took this to the Nuclear Energy Advisory Committee back in 2016. They reviewed the overall program and gave a resounding proceed forward immediately on conceptual design of a new test reactor, which we did.

The recent and full creation from Congress on the Omnibus Bill provided $35 million to start an R&D program. We kicked off the program in April of this year and we plan to have a three-year R&D program that is going to put together the details of the overall core and functions of that reactor. Specifically, we will work very carefully with the vendors to identify what needs do they have in looking at various coolants, various fuels, various materials, and we will do that very early on.

We also plan to word very early on with the Nuclear Regulatory Commission in parallel as we, the Department, license the reactor.

I've had recent discussions in this particular area and I'm putting together a framework of cooperation so that they can attend the appropriate meetings on safety and design.

We have not made a decision that we're going to build this reactor but we will make that decision after a three-year study identifying the true costs of schedule of that particular reactor.

In closing, I would like to say there are profound opportunities for new nuclear growth. We see the picture today and we have strong global markets interested in these vast technologies.

And most importantly, we believe the U.S. leadership to ensure safety; non-proliferation is paramount in our overall program.

The administration, as I said earlier, is firmly committed to nuclear energy and we look forward to your questions at the end of this meeting.

CHAIRMAN SVINICKI: Thank you very much. Dr. Baranwal, please proceed?

DR. BARANWAL: Good morning, my name is Rita Baranwal.

I'm the Director of GAIN, the Gateway for Accelerated Innovation in Nuclear, and thank you for this opportunity for me to share with you a bit about what GAIN is and what we've been doing.

GAIN was launched a few years ago to address several issues, national and global demand for nuclear energy is increasing, and frankly, the U.S. global leadership is eroding.

There's a sense of urgency with respect to the deployment of the innovative nuclear energy technologies that are being developed, and an effective private/public partnership is required to achieve these goals.

Next slide, please. GAIN's mission is to provide the nuclear energy industry with access to the technical, regulatory, and financial support that's necessary to move innovative nuclear energy technologies towards commercialization in an accelerated and cost-effective fashion.

GAIN is the organizing principle for relevant, Federally-funded nuclear energy research, development, and deployment programs.

Additionally, GAIN is a private public partnership framework that's aimed at rapid and cost-effective development of innovative nuclear energy technologies towards market readiness.

Next slide, please. GAIN is striving to simultaneously achieve three goals. One, we aim to assist the Department of Energy and the U.S. nuclear industry become leaders in global technology commercialization once again.

Two, we strive to include our supply chain vendors while developing new concepts to aid in the deployment process and ensure global industrial leadership.

And three, we seek to optimize the U.S. domestic energy portfolio by including utilities and end users during technology development within GAIN.

Next slide, please. More specifically, GAIN provides innovators and investors access to the national laboratory capabilities in the areas of modeling and simulation, design and support, reactor and fuel cycle research programs, experimentation, and an NRC interface.

This work helps both the innovators and the NRC in determining licensing technical requirements, increasing licensing readiness levels, and reducing regulatory risk.

Next slide, please. So, the connection between DOE and NRC includes DOE's support of technology-inclusive and cross-cutting areas.

The relationship between GAIN's strategic goal of maintaining DOE state-of-the-art capabilities and its strategic goal of providing industry stakeholders access to those facilities.

We can progress to the next two clicks. One more, thank you. So, shown here in the red boxes and the NRC's general views of what's needed for licensing are closely coupled.

Next click, please. One more. And the blue box connects the more technology-inclusive and generic efforts from GAIN's strategic goal to support development of a technology-inclusive regulatory framework.

I'd also like to recognize NRC's efforts in conjunction with the Department of Energy for the licensing modernization project interactions to establish critical regulatory guidance.

This first foundational step towards a risk-informed, performance-based regulatory framework will provide a technology-independent alternative that will be crucial to the deployment of advanced reactors.

GAIN also appreciates the DOE and the NRC efforts for developing the recently published Regulatory Guide, 1.232, Guidance for Developing Principled Design Criteria for Non-Light-Water-Reactors, which provides acceptable means to develop design criteria for advanced Non-Light-Water reactors. Next slide, please.

So, if I can have the next three clicks? I'm highlighting some of the examples of GAIN's support to industry, and these include vouchers for national laboratory work that will assist companies with their design licensing processes, including development of a mechanistic source term, evaluation of power-pumping technologies, and fuel salt characterization, just as some examples.

Next slide, please. One of GAIN's primary objectives is to grant innovators access to DOE laboratory facilities and expertise. Some examples of this include accident tolerant fuels.

New ATF cladding was conceived, developed, manufactured, and tested at Oak Ridge National Laboratory and has been manufactured by Global Nuclear Fuels into lead test assemblies, has been shipped to Southern Nuclear Operating Company for trials in the Edwin Hatch Plant.

FeCrAl cladding, known as iron clad, will be the first developed through the DOE's enhanced accident-tolerant fuel program to be installed in a commercial nuclear reactor.

Molten salt reactor development, including training on MSR technology and the molten salt reactor experience, has been provided to the NRC via a series of training courses.

We continue to support the ARC-15 funding opportunity announcement with TerraPower on MSR technology development, including material development, corrosion expertise, salt properties, modeling and simulation, and safeguards.

And in the area of database development, Legacy Fast Reactor data including EBR-2 reactor physics and fuel performance data, as well as creep data on fuel-transient testing.

And post-test examination has been provided, GAIN's supported completion and activation of the creep database, TREXR, for benefit of industry users.

Next slide, please. On November 10 of 2016, DOE and NRC signed a memo of understanding wherein the NRC provides DOE and the GAIN community with current accurate information on NRC licensing processes and regulations.

This MOU enabled GAIN to have a regulatory tab on our website, wherein anyone can ask a question of the NRC. We send those questions to your Staff who provide us back a reply to post under the FAQs on the GAIN website.

I would like to thank the NRC Staff for working with and educating the GAIN Advanced Reactor community via the regular public stakeholder meetings that are held about every six weeks.

These meetings have been invaluable for the GAIN community. Final slide, please.

Finally, GAIN looks forward to continued engagement with the NRC Staff to accelerate deployment of advanced reactors via the NRC's public stakeholder meetings and workshops, the most near term of which will occur with the American Nuclear Society on May 2nd on developing a strategic vision for advanced reactor standards.

Thank you.

CHAIRMAN SVINICKI: Thank you very much. Dr. Shahrokhi, please proceed.

DR. SHAHROKHI: Good morning, my name is Farshid Shahrokhi, I'm the Director of High Temperature Gas Cooled Reactor Technology at Framatome.

Today, I represent the High-Temperature Gas Cooled Reactor Technology Working Group. We are an independent industry group formed within the NEI Advanced Reactor Working Group.

Our membership includes high-temperature reactor developers, coated particle fuel manufacturer, and a utility. We also have representatives from EPRI, DOE, and NEI.

Our mission is to express and support our Members' common technical and R&D needs. We have engaged and interacted with the DOE research communities, the universities, the standards developed in communities, and the NRC.

Our reactor designs use helium as the coolant or molten salt in case of Kairos Power. Graphite moderator and uranium oxycarbide, tri-isotropic or TRISO-coated particle fuel as our basic fuel form.

Our designs produce high-temperature steam under the order of 560 degrees Centigrade, provide a high-efficiency electricity production or industrial process heat.

Our reactors are modular and small, ranging in power from 10 megawatts to 275 megawatts. Next slide, please. I would like to first thank the NRC Staff for working with us and the other advanced reactor communities in an effort to modernize and risk-inform our regulatory infrastructure.

This work is important to us because we need guidance that applies to our reactor designs, as opposed to the current guidance that evolved over the past 50 years through licensing many Light-Water reactors.

Risk-informed and performance space guidance for Non-Light-Water reactor, licensing basis development will provide a systematic process for demonstrating satisfaction of existing regulations that we could use, independent of any specific reactor technology.

The work the NRC is doing with support from the Licensing Modernization Project, supported by DOE, is a major step forward in the long-term goal of technology-inclusive regulatory structure.

For the near term, we support and applaud the DOE-NRC efforts for developing and publishing earlier this month the Regulatory Guide 1.232, titled "Guidance for Developing Principled Design Criteria for Non-Light-Water Reactors."

This guide provides acceptable ways for developing principled design criteria for a range of advanced reactor designs, including our modular high-temperature gas reactor.

Within our developer community, the interim results from the DoE TRISO particle fuel qualification program mentioned earlier, and characterization known as the DOE-AGR program, show that the reactors that use a combination of TRISO fuel, graphite core, and a single-phase chemically inert coolant could have an extraordinary low radiological source term.

This enables enhanced operational capacity and accident tolerance, which is foundation for our alternative radionuclide retention strategy and performance criteria definition.

The so-called functional containment is an independent set of systems, structures, and components, working together to retain fission products and limit those at the site boundary to less than one gram for all anticipated operational occurences design basis and beyond design basis accident scenarios without relying on pressure-retaining reactor buildings.

Of course, one gram is the EPA PAG limit and is our design goal. We have worked with the NEI and the NRC Staff to establish a radionuclide retention strategy using the concept of functional containment for Non-Light-Water-Reactors.

A draft Commission paper titled, “Functional Containment Performance criteria,” is working its way through the NRC regulatory review and approval chain.

Acceptance of functional containment for radionuclide retention is an essential part of our reactor concept development and commercialization. Our Technology Working Group is also collaborating with the DOE Idaho National Lab and the Electric Power Research Institute in preparation of a limited-scope topical report to be submitted to the NRC early next year in 2019 for off-fee review and approval.

This report will be a generic topical report documenting the completed part of the TRISO fuel testing results at Idaho National Lab.

Once reviewed and approved, each developer that wishes to use UCO and TRISO fuel, UCO-based TRISO fuel, can reference this topical in this design-specific fuel qualification report.

The HDGR Technology Working Group also recognizes that further advanced reactor regulatory development with the goal of reduction of regulatory uncertainty will continue to require close collaboration, coordination, and interaction with industry.

This is evident by our past and ongoing engagement with the consensus standards communities, such as ANS and ASME. We have proposed and encouraged an NRC review and the endorsement of one of our key standards, the ASME Section 3 Division 5 for high-temperature reactors.

In coming years, we will continue our engagement with the NRC Staff to further develop cross-cutting improvements such as safety-focused regulatory reviews, emergency planning, staffing, and security requirements for advanced reactors to further reduce regulatory uncertainties and encourage deployment of advanced reactors.

Thank you.

CHAIRMAN SVINICKI: Thank you very much. Next we'll hear from Dr. DeWitte. Please proceed.

DR. DEWITTE: Thank you, and thank you for the opportunity to be here. My name is Jacob DeWitte, I'm the CEO and co-founder of Oklo and I'm here representing the Fast Reactor Working Group Today. So, next slide, please.

The Fast Reactor Working Group includes multiple developers who are working on multiple technologies that span the spectrum of fast reactor development and it is growing to also include various stakeholders beyond just the developers engaged, including utilities, as well as suppliers and vendors, as well as other stakeholders.

These technologies span the spectrum of fast reactors under consideration, meaning we have liquid-metal-cooled systems, gas-cooled systems, as well as salt-cooled and salt-fueled systems under consideration.

Next slide, please. Some of the activities we've been mostly focused on to date have worked around developing our understanding needs and capability sets, and growing those to support the deployment and commercialization of these technologies.

And since these technologies often span a wide range of technology and material readiness, the needs vary considerably. So, I'll highlight a summary of those here for you today.

One of the highlighted efforts here is really focused on fuels, considering that's often one of the longer poles in the tent.

When you look at the technologies being developed by the fast reactor developers, they span a variety of fuels as well, from metals to nitrides to oxides to carbides to salts.

Most of those have some degree of radiation experience and prototypic conditions or near prototypic conditions but often, that's very limited and lacking.

So, there's quite a bit of work going on to expand our understanding, not just of the fundamental phenomenology but also the operational characteristics.

The restart of TREAT was a tremendous step in the right direction to enhancing our capabilities for research and development to support the transient testing and qualification of new fuel forms that are being developed, and also advancing the fuel forms that have a fairly mature and rigorous base behind them, such as metallic and oxide fuels.

Furthermore, we're working to expand and open up the opportunities for research and development infrastructure including, for example, the versatile test reactor as well as other facilities that are possessed in our national laboratory system that support fuel development and qualification.

On top of that, since some of these fuels are very mature and have a rich legacy behind them, there's a lot of work going on in getting access to the tremendous amounts of radiation data that was generated over the past 50 to 60 years in this country's fast reactor development program, and I'll touch on that in a minute.

Another aspect that we've been focused on is expanding out the capabilities we have available for modeling and simulation, building upon both these existing tools as well as new tools that can be developed to enhance what we can do in our design suites as well as analysis suites.

It's important to highlight that some of these tools have tremendously high fidelity capabilities, which also limit their use to some degree in both the analysis space as well as the regulatory space.

So, translating those and using those into a more useable state is going to be an important factor here.

On top of that is the uncertainties that go with those tools.

Sometimes we may be able to model and simulate a system to such a high degree of fidelity, (unintelligible) washed out by the underlying uncertainties in just the thermophysical properties of the materials being used.

So, coupling what we have today with what we're developing now and what we'll have available tomorrow are important aspects of what we're trying to focus on. And spanning that bridge, it's a continuum of development when it comes to modeling and simulation tools.

Furthermore, some designs have a very mature modeling and simulation base behind them and others need more work to enhance the capabilities to suit their needs.

Touching on legacy data, I mentioned that earlier, that's a very important piece, especially for metal-fueled designers. So, specifically, there's seven developers that are considering using metal fuel in their designs.

Uranium and zirconium alloy is the predominant use case there. That fuel form has a long history of development and qualification in this country's fast reactor programs.

And the data that was generated from EBR-2 predominantly, but also FFTF and other radiation campaigns that have gone on next to that, including TREAT for example, as well as out-of-pile tests, is tremendously valuable for the developers pursuing that technology, and provides the fundamental case, safety case, for why these reactors can operate the way they can.

Thankfully, there's work being done by Argonne National Laboratory to develop that database and make it available, both with what Rita mentioned with the TREAT database, but also the EBR-2 field performance databases.

And we're working with DOE to expand the data that we can put into those databases and make it available for not just developers and the public, but also the regulators.

Related to that, we support a virtual test reactor; we think that will be a tremendous boon for the development of advanced reactor technologies and spur quite a bit of innovation in terms of not just brand-new technologies but also evolving the technologies that have a more mature base behind them.

Furthermore, we have been mapping out the various standards, needs, and opportunities we pursue and we see as important for the development and de-risking the regulatory risk for fast reactor developers.

One aspect that we endorse is the pursuit of this ASME Section 3 Division 5 for higher-temperature operations. That affects a variety of the developers and is something that we will be participating in next week in the panel, and advocating for.

And finally, we'd like to log the work being undertaken by both DOE as well as the industry in conjunction working with the NRC to both adopt new frameworks and guidance for basically the Non-Light-Water-Reactor design criteria but also the licensing modernization efforts that are going on, including, for example, the functional containment effort that Farshid mentioned, as well as the other piece of the industry-led licensing modernization efforts.

There's a lot of value that comes from those in terms of providing more flexibility in terms of how designs can demonstrate safety, as well as the case to demonstrate safety more adequately and more thoroughly.

The inherent and passive nature that many designs employ from beginning is an important characteristic to capture accurately and some of these advanced, I would say, frameworks and guidance allows us to do that fairly rigorously.

So, with that, I end my presentation. Thank you.

CHAIRMAN SVINICKI: Thank you very much. Mr. Irvin, please proceed?

MR. IRVIN: Thank you for the opportunity to be here. My name is Nick Irvin, I am the Director of the Advanced Energy Systems R&D Program at Southern Company. Today I am here representing the molten-salt reactor technology Working Group at NEI.

We're here today because we believe molten-salt reactors have an opportunity to provide a great future for nuclear energy.

We saw this several years ago with our R&D program and decided to inject ourselves into that program and support the innovation in this space.

Next slide, please. The Molten-Salt Reactor Technology Working Group is a very diverse group. It represents I think the heart of what innovation is in the nuclear space.

There are eight technology developers represented on this team and they are very diverse in both their reactor design but also in their makeup as a company. We also have representation from multiple utilities as well as EPRI on the team.

Next slide, please. Similar to Jake, with this broad diverse set of players, we have decided to highlight some of the activities going on within the group. I've laid them out here for you.

One of the important activities that we have been participating in and I think is very important as we look forward to commercializing these technologies is the integration of the gap analysis and closure plan of NUREG 1537 to support test reactor licensing.

Many of these designs are fairly young in the development cycle and there is a recognition that some of them may require a test reactor campaign to support the licensing of the commercial technology. And so that's a very important piece of work that's been going on for some time and we see as an important part going forward.

In a similar vein, as Jake mentioned, we are very supportive of the development of the risk-informed performance-based regulatory structure. An important aspect of that is the work being led by Southern Company on the licensing modernization project.

We believe those results are very promising and they provide a high potential to give us a consistent and transparent framework going forward for licensing these advanced reactors in the future. Similar to both Jake and Farshid, we also support the regulatory guidance for functional containment that's underway right now.

MSRs are a different beast in that this community is a group of folks who have liquid fuel designs. And so fuel qualification is an important question for us.

We're currently working with DOE and others in the community to establish a basis for how those liquid fuels would be qualified.

What are the critical characteristics to support that qualification? The network will be important as we go forward, both in test reactor and in commercial reactor licensing.

Modeling simulation is another way that MSRs may require some different tools. We actually, the MSR Working Group, was hosted by the NEAMS program last month and had a great workshop on how we can use the NEAMS tools to support modeling simulation for these reactors.

We support this ongoing work and encourage the use of these tools. We think they have a great potential to provide us a basis from which to design and license these machines.

Further, we're also working with the ANS program to support the 20.2 standard, which is to provide the design criteria for AMSRs.

Largely, the goal would be to have a largely risk-informed performance base standard there to where you could use it in any way possible. We think that work is important for the commercialization of the technology as well.

And last but not least, there is a consistent need across most of the designs for the use of high-assay LEU fuel, whether it be for support of the test reactors or even ultimately, the commercial reactors in this space.

So, with that, I'll close by just saying that MSRs, again, offer this great potential with a very diverse set of needs.

We think these are the most important ones that we've consolidated on as a group, and we thank you for your time.

CHAIRMAN SVINICKI: Next, we'll hear from Dr. Lyman. Please proceed when you're ready.

DR. LYMAN: Yes, good morning and thanks again to the Commission for inviting us to present our views on this set of very important issues. Next slide, please.

So, our overall position on advanced reactors and just to set the context, it's very important to separate hype from reality in this particular area. So, that's what we strive to do.

All Non-Light Water Reactor concepts I'm aware of have potentially some advantages, but also disadvantages compared to Light Water Reactors. And one has to understand the totality of those differences to really assess their overall safety.

All Non-Light Water Reactors have novel features whose behavior will require significant testing analysis to quantify margins and uncertainties for licensing purposes.

And at this point, even though many of these designs have been brought to various stages of development over many decades, there's still no technical basis to say that any, either gas-cooled reactors, fast reactors, or molten-salt reactors will be inherently safer or more secure than

Light-Water Reactors.

In fact, there's good reason to believe from any of those groups of designs that they have characteristics that could well make them less safe and secure, meaning that at least for the first generation of deployment, they would require compensatory measures to ensure a comparable level of safety to Light-Water Reactors.

Next slide, please.

Our belief is that the NRC's regulatory processes for licensing are sound but they're being unfairly maligned as significant obstacles to advanced reactor deployment.

In fact, we see the main barriers or the fact that huge investments in both cost and time are required for any Non-Light Water Reactor vendor to develop a concept to the level of maturity needed to support a high-quality application.

And the burden is on the vendor. It's not up to the NRC to weaken their licensing standards so that they can accept a less robust application, just to expedite advanced reactor licensing.

We think that line of thinking is unnecessary and potentially dangerous. And we also are concerned about efforts in Congress to promote deployment of demonstration reactors without NRC licensing authority based on a reading of the Atomic Energy Act we may not agree with.

So we think that Congress really needs to ensure that the NRC will have licensing authority over that next generate of reactors, even if technically, under the AEA they would not be given that authority a priori.

Next slide, please. So, expectation versus reality.

The NRC has already made statements and documents like the final regulatory basis for the emergency preparedness rulemaking for SMRs and other new technologies that state this assumption that new designs typically have lower probabilities of severe accidents which would also lower their impacts to build with health and safety.

We think this is an unverified and likely false assertion at this point and we'd like to point out that the advanced reactor policy statement has an expectation that new reactors will be safer, but it does not have a requirement.

So, you may expect to get something but you may not actually get it when it comes.  You have to validate that for any regulatory decision.

Next slide, please.  In fact, this can become a self-defeating prophecy because even if designs have some additional inherent safety features, the overall safety of the design is still going to depend on how the NRC comes out on these policy decisions involving citing.

And I'd say we don't think revisiting the Commission's position on urban intensely-populated areas is necessarily a good strategy.

The issue of functional containment is something that concerns us greatly and other changes to the design criteria which may sweep under the rug certain uncertainties that are long-known for these designs, issues of emergency preparedness and the issues of security, how Probabilistic Risk Assessment is credited in licensing, the level of testing requirements that are accepted, and also special treatment and the allowance of non-safety-related systems based on, again, these presumptions that the reactor is safer.

And we think overall, if you reduce safety margin defense and depth by making decisions in the wrong way that could undermine the overall safety of these designs.

So we think certainly for the first-of-a-kind demonstration reactors, they should be regarded as prototypes and the NRC should ensure that there are additional safety features to compensate for these uncertainties. Next slide, please.

And just pointing out for each class, gas-cooled reactors can be seriously damaged by air or water ingress and that's a category of accident or sabotaged events that need further consideration.

Liquid sodium-cooled fast reactors have inherent reactivity instabilities as well as flammable coolant. Molten-salt reactors have to be kept in a narrow temperature range and if they heat up, if there's a coolant clot that freezes, then the reactor can destroy itself within ten minutes.

So, the window is pretty slim there. And you also have to consider the implications for the entire fuel cycle and certainly any designs that involve co-located reprocessing or the use of strategic special nuclear materials in the fuel cycle are going to raise novel security issues.

Next slide, please. On risk-informing reactor licensing, the fact of the matter is that PRAs for any Non-Light-Water design are largely still academic exercises and lack sufficient data for validation.

And it's hard to define even what a design-basis accident is; certainly, to understand severe accident progression consequences are a long way off.

So, for first-of-a-kind reactor licensing, we think there's very little utility in using risk information except in a very general way.

And over time, however, as operating experience becomes available and the validation of PRAs becomes stronger, you may increase their use in applications.

Next slide, please. One area we're very concerned about is the potential Non-Light-Water-Reactor Security Rulemaking, again based on the presumption that advanced reactors are going to be safer.

And there are proposals that perhaps advanced reactors will not require to protect against the design basis thread and certainly would not need to demonstrate that through force-on-force performance evaluations.

We think the current regulatory framework is already flexible enough to accommodate exemptions or exceptions from the current rule, so we don't think the rulemaking is necessarily appropriate.

And certainly less vendors can document or have a proof of principle that there's a reactor that can't be sabotaged and will lead to a large radiological release. We think that rulemaking is premature. Next slide, please.

Finally, on the issue of secrecy, my experience in the past is that reactors that have come to the NRC in pre-application reviews have provided much more basic information about the designs which is very helpful for the public to start getting a sense of the safety basis for these reactors.

I'd point out the Toshiba 4S during pre-application provided a considerable amount of information that we don't see in current pre-application reviews, for instance, with Oklo.

And we're wondering why the standards for proprietary information may have become stricter and we think that this may need to be challenged.

Also, since the vendors will have to release more information eventually if they pursue licensing, if they want to engage with the NRC early, why not engage with the public early and be more transparent early in that process?

So, I'll stop there and I apologize for exceeding my time.

Thank you.

CHAIRMAN SVINICKI: Thank you very much, Dr. Lyman, for that presentation and to all of the panelists for your presentations.

It's the practice of our Commission to rotate the order of recognition for Q&A, and today we begin with Commissioner Burns.

COMMISSIONER BURNS: Thank you all for being here this morning and for the perspectives you've brought on the advanced reactor reviews.

It is certainly an area, since I returned to the Agency in 2014, that it's gotten much more attention, much more attention, and also concentration by the Staff as various people in the community have sought to bring forward the potential for new designs. And I appreciate the work with our partner Agency, the Department of Energy, in terms of the cooperation we've had, and being able to provide the link through the GAIN initiative for that.

Let me start out with a few questions first for Dr. Herczeg.

Could you give me a little bit more in terms of what's the conception in terms of micro-reactors and the applications for them?

DR. HERCZEG: Thank you, Commissioner Burns. The micro-reactors that we've looked at so far, and these are people who come in and give us overview presentations, are in the conceptual design phase but they are small enough that they could accelerate it to building very quickly.

The applications that they're looking at are in primarily remote sites right now like Alaska, which as you know, 4S has been looking at for number years. But it turns out that the Defense Department is also looking at this application for islands or small places that they need power.

As you well know, the transport of that fuel costs many, many lives.

And so if we can get transportable reactors into I won't say a forward basis at this point in time, but just the main basis.

This is a way to not only help an environmentally clean release of energy for the site but it also provides the capability to quickly move them in and out.

As part of the overall designs we're looking at, they have to be transportable in an aircraft, they have to have enough shielding so they are not giving radiation to the people.

We also are making sure that the containment is such that it will not, even if there is some sort of explosive that's made nearby, disperse fission products in the overall area.

These are heat-pipe designs and, well, I should say two of them are heat-pipe designs, the third is a turbine design.

The heat pipes look very robust, there's a lot of technology going on.

We're testing those right now at the Sandia National Laboratory. I think that we will have to look at that technology and try to determine its viability by actually building and demonstrating one.

And in doing so, we'll work closely with the NRC to make sure that it meets the standards of the NRC.

COMMISSIONER BURNS: Okay, thanks very much. And I think for Dr. Baranwal, one of the things I think we've been able to take advantage of is some training on the molten salt technology for the NRC Staff.

Are there other areas you thought there might be opportunities for our Staff to obtain training or other aspects from the DOE programs that would have a benefit for us?

DR. BARANWAL: I think that certainly, yes, in the areas of fast reactors there is training, especially on the advances that have occurred over the past, I'd say, decade that could be developed and offered.

And I think with respect to the fuel qualification aspects for the high-temperature gas arena, certainly we can apprise your Staff of the activities and results going on in that arena.

Not to indicate that there's a deficiency necessary on the NRC side but just to keep all of your Staff apprised of the progress that's been made in these technologies.

COMMISSIONER BURNS: Okay, thanks very much. I think there were a number of people that mentioned the Regulatory Guide, I'm going to probably get the number wrong, 1.123.

PARTICIPANT: 232.

COMMISSIONER BURNS: 232, okay. Great, I'll put that in my head there. So, on the Regulatory Guide, which really came out of the initiative, we had cooperation or we took into account the DOE assessment on the general design criteria.

And then looking at that and how that would then fit in terms of the review aspects for advanced reactors. I think it's a big step, I'll put it to the Working Groups here.

What are the other big steps you think that need to come from the NRC with respect to either licensing-type criteria or consideration of where we go with that?

DR. SHAHROKHI: One of the things that we would like for the short term, the 1.232 is very good for us. It provides us ways, acceptable ways to prepare our principled design criteria for early adopters.

Risk-informing the regulation is very important to us, their licensing modernization project, developed by, sponsored by DOE, is important to us. Engagement of the Staff with that project is quite important.

There is a guidance being prepared as we speak to prepare a Reg Guide or a SECY for this project to say how do you provide risk-informed performance-based structure for regulations?

So, those two, and also the functional containment; our design is different from Light-Water Reactors, our radionuclide retention strategy is different.

So we need a different way of retaining a radionuclide, and functional containment is that way. And the preparation of the Commission paper on that describes that and so we encourage endorsement of that paper.

COMMISSIONER BURNS: Anybody want to take --

DR. DEWITTE: I would just echo that and say for the various technologies being pursued by the Fast Reactor Working Group, all of those align with the interests.

And people are kind of expressing specific requirements, specific need-sets in terms of clarity and definition in some of these areas will be provided specifically.

For example, functional containment, risk-informed performance base, development frameworks for regulations as well as 123 and 1.232 is a very good first step.

I think longer term, there's a few opportunities with regards to citing discussions but that's something that falls in I think a little bit later. These early ones are more important for the near term.

COMMISSIONER BURNS: Okay, Mr. Irvin?

MR. IRVIN: I'll echo these two guys with the one addition.

As I mentioned earlier, the use of NUREG 1537 and the work that's been done to date on that for supporting potential test reactor applications for the MSR community is probably the last thing to add.

COMMISSIONER BURNS: Okay, thanks. Dr. Lyman, in your presentation, you note in a number of areas there is a concern about what ultimately licensing standards and technology standards are.

So, I may have an understanding from the slides and from the discussion you have.

What would you say are the biggest ones or the most significant ones that you see right now that have a challenge in terms of either maintaining or improving safety where you think there's if I can use the word backsliding?

DR. LYMAN: Yes, well, I think some of the issues that have come up already, for instance, functional containment and how it's defined, how the current deterministic criteria for pressure-resistant containment may be waived, and what you would accept to make that kind of a major change?

In other words, reactivity control and how you define inherent reactivity feedback and the timescales, which are very important for some of the fast reactor safety cases we've heard about.

And with regards to molten salt, the very nature of core damage and how you define fission product releases and also how you treat co-located essentially reprocessing plants, and they are both safety and security implications. So, those are some of the ones that come to mind.

COMMISSIONER BURNS: And on the latter, reprocessing, your concern is the security or non-proliferation concern?

DR. LYMAN: Primarily, but there's also a safety case, for instance. My preference is keep fuel solid so when the molten-salt vendors go out and say our fuel can't melt down, well, that's because it's already molten.

But that isn't necessarily an advantage unless you can compensate for the fission product retention properties as solid fuel.

So, you're going to have to substitute other barriers for the barrier that's solid fuel in the cladding and that is going to require certain assumptions on the part of the NRC as to how you will accept this change of barriers.

COMMISSIONER BURNS: Okay, and if I could, one last question, one of the I think concerns that Dr. Lyman noted was in terms of the PRAs, whether or not there's sufficient experience or data.

How does historical data -- I think Dr. Dewitte noted that we're trying to in effect mine that data.

And I think actually, Dr. Baranwal, how does that address or help address, it may not give you a long period of experience or it may be more limited experience, but does that help to inform your development of the PRAs?

Is that what you're looking for in trying to get your hands on that data? Help me out on that.

DR. DEWITTE: Yes, the PRA actually is more of a way of identifying what is the fundamental basically performance and really, how the system behaves.

Less so depending on exactly the data and component reliability data as much as it illustrates how PRA can be used to identify safety and progression of events, and what you need to do with that.

An important characteristics of a lot of these advanced reactors is what you look at the inherent safety capability sets in there, you don't need to have a lot of active componentry involved to keep the system in the safe state.

And as a result, the data that comes out from these legacy experiments is more built for operational perspectives and to drive testing programs, but less so needed for the development of complete and adequate PRA.

COMMISSIONER BURNS: Rita, anything on that?

DR. BARANWAL: Just that GAIN is trying to provide access to that legacy data, to the historical data in an adequate appropriate format to the developers so that they can continue to accelerate their designs and not have to, so to speak, reinvent the wheel.

COMMISSIONER BURNS: Okay, thanks very much, thank you, Chairman.

CHAIRMAN SVINICKI: Well, thank you all for your presentations.

I was reflecting on a few things as I listened and I appreciated that we have the different Working Groups that are representing the different categories that kind of roll up to the overall diversity of the designs that are under pursuit and development now.

It would be easy to be overwhelmed when I think about the foundation that we need to build to make the kind of safety determinations that NRC makes. It would be easy to be overwhelmed with the body of work that is needed for any one design, much less across the spectrum of the design variation. However, there is a body of work that can be of benefit to all the different Working Groups and types of designs. And I conclude that NRC and DOE have focused on that as the highest priority. And what do I mean by the kind of major work efforts?

I'm bidding them as kind of data standards, codes, and then there is this kind of overhang of fuel development or the high-assay LAU which hangs out.

There's a need, probably sooner rather than later, creeping up on a lot of the development programs.

An interesting historical fact, of course, is a number of these reactor types were explored many decades ago with the United States, which I'm intrigued by trying to develop modern-day pedigrees for legacy data.

I know that Oklo's been working on that with Argonne for some time. It's an interesting exercise.

I was contacted recently by a friend and former colleague, Dr. Pete Lyons, and so I shouldn't attribute this to him in case I'm not remembering what he told me correctly, but he said for some of the encapsulated fuel types like the predecessors of TRISO fuel, some of that data and work goes back to 1947, which was even earlier.

And that's kind of what he was commenting to me, is how interesting that is. So, that's I think a significant undertaking to develop a pedigree around that. I'm not saying it can't be done, but there's a lot of work there.

Standards development, I probably don't follow as closely, but there is a law, U.S. law, the citation to which I've forgotten in the moment, which as a regulator, in essence, the theory of this or the requirement of this law is that we are required to utilize consensus-endorsed standards.

And if we're not going to use them in our safety work, then we have to justify why they were not sufficient.

And then codes, there's this disconnect as I understand it, and I'm going to ask a question in a minute.

But there's this disconnect in code development historically in that AEC, Atomic Energy Commission, and DOE work today is more orientated around normal operating regimes, meaning if you're going to develop the technology, you want to have high fidelity codes to model it around how it's going to operate you hope most of the time.

NRC has been more focused on the far edges, which is systems under stress, severe accidents scenarios, or just off normal events. And so as we look, as NRC and DOE, at bringing some of that work or bridging it, I'd be curious if anyone has a comment? I know those discussions are underway. How is that going? I have a personal view that given the computing power now, the development of a code is a very substantial exercise and therefore, I think the notion that different Government Agencies will have their own codes is not likely to be supportable.

And so what I'm trying to solve is the problem of how can we have a suite of high-fidelity instruments or tools computationally that can meet the needs of, again, the regulator, which are on these far edges, and then also be useful for the large technology development work that's done by the Department of Energy.

So, in that broad suite of data, standards, codes, the fuel issue of the high-assay LEU, is there something that any commenter would like to say as to where should NRC be focusing more of its orientation and less of its orientation on kind of that suite of problems to be solved?

And Dr. Baranwal, you were nodding vigorously during parts of that. Would you like to start?

DR. BARANWAL: Sure, I'll start.

So, with respect to the modern-day pedigree for legacy fuel data, I think that is a very important aspect going back to my earlier comment where we really need to take advantage of the wealth of information that is available within the National Laboratory complex, modernize it and make sure it's acceptable for use in today's designs.

We have a general sense of the quality assurance standards.

Again, I have a view in studying the history that this nation, when it didn't have a lot of computational power, we had a core of tremendously creative and smart experimentalists.

And so that was the historic strength, I think, of a lot of our scientific foundations and maybe now we've migrated more to analysis to complement the experimentation.

But were the general practices on quality assurance, were they fairly high back in the '50s and '60s, maybe the '40s? I don't know.

CHAIRMAN SVINICKI: It varies.

DR. BARANWAL: Unfortunately, I can't speak to that. I think Dr. DeWitte might be closer to it since they're working with that data.

DR. DEWITTE: Sure, I'll jump in. So, a lot of the data that spans back to that era, I would say '50s, '60s, there were at that time QA protocols. I wouldn't say they were sufficient for use today.

I would say, though, that there's insights learned from that that were also carried through to inform the experimental development work that happened in the '80s and '90s and through now, which did apply QA protocols and programs that resemble more what's done today and what's expected today.

And there are processes by which you can take that data and show basically quality sufficiency and kind of exceed what the expectation is using that old data.

Rigorous records are often kept, experimental drawings, diagrams, experimental notes and records are all maintained and these are what are being put into databases.

So, they can be accessed, taken through a subject-matter expert review among one of several tools you can use to actually take that data and show modern QA equivalency I would say.

On top of that, the other thing that is of interest is that some of the work done by Idaho and Argonne together has shown with modern radiation you can do flex filters, for example, with the advanced test reactor and get a fast enough spectrum to show that the way the fuel behaves in terms of how fission is going on is the same as what we saw before.

And so that complements. You can trace that through and show quality --

CHAIRMAN SVINICKI: Kind of a validation step that allows you to kind of look at and convince yourself of the integrity of the experimental methodologies and the data-capture and things like that.

DR. DEWITTE: Exactly.

CHAIRMAN SVINICKI: I think, Dr. DeWitte, your presentation had talked or you focused quite a bit on modeling and simulation.

Do you have any comment to make about my codes, the different kind of overall orientation towards codes utility by DOE and NRC?

DR. DEWITTE: Yes, I think that's a very good point but I think one thing I would add onto that is some of the work going on right now with the modern frameworks that the DOE's pursuing for their tools, particularly under the MOOSE framework, is applying the flexibility.

And I would say the robustness and resiliency in these tools to capture the physics at the edge of what we expect, as well as applying modern I would say uncertainty quantification and qualification as well as actually dynamic PRA tools allows us to really push the edges there and understand where we go on that and kind of get out to the cases that are most interested but preserve the physics of the system. And that's the key aspects of what needs to happen here.

So, I think building on what's going on there provides the need cases there and we just have to keep expanding that and ultimately using it.

CHAIRMAN SVINICKI: Do you think it's fair to say -- from our accident tolerant fields meeting I developed a sense that maybe the codes development right now is akin to what we've gone to in this country with user facilities for experimental capacity meaning that it's one facility but many users.

It tries to meet the needs of many users coming forward so that with codes development, you're trying to have one high fidelity suite that is well validated.

And therefore, whether you're looking at the margin effects for the regulator or other effects for the developer, you just would have invested all the orientation in getting a highly-validated suite of codes for us by everybody.

And I think there's strengths in terms of the overall integrity analytically to that approach. Is that kind of what's happening? Do I draw the right conclusion about that, Dr. Baranwal?

DR. BARANWAL: There is a suite of tools being developed and the beauty of it is that as Mr. Irvin alluded to, we are working with not only the technology developers but they're coming in and working with the code developers to ensure that we are developing the codes to meet the technology's needs. So, it is not only the design basis but also the extreme accident scenarios that the NRC will expect them to come prepared with.

CHAIRMAN SVINICKI: Okay, thank you.

DR. DEWITTE: And I would just like to add that one of the important things, too, from a methods and development perspective, an actual code development perspective, is using modern software development techniques allows what's happened, for example, the MOOSE framework, to build out a broad framework.

But then you can plug in different modules of interest for each system of interest. And I think that's part of the powerful capabilities and flexibility we're seeing with these modern tools. You're developing a modern computation architecture with modern software development architecture.

CHAIRMAN SVINICKI: Okay, thank you for that. And the NRC Staff published a roadmap last December and they focused a chapter of that on getting very precise about terminology about what is a prototype, what is a demonstration, what is a test reactor.

So I mentioned that only because I can't remember the precision of those definitions so I'm just going to use prototype and demonstration which a very general terminology here.

But the interesting point about the history, that many of these new advanced reactors actually were investigated by the United States many years ago, it seems to me that we did a lot more prototyping and demonstrating.

Is that just too expensive to do today or is it that we have the computational power and therefore, we feel we can do much more targeted system-by-system research or material-by-material research and we don't need to build the integrated physical thing to demonstrate?

It's a little philosophical but I feel like the history, a lot of the work today stands on the shoulders of so much of that experimental work. Again, having spent some time out in Idaho, I know that 52 I think different reactors were demonstrated out there.

So, is there going to be no parallel to that in the modern age of reactors? Is that not needed anymore?

DR. SHAHROKHI: For us in the HTGR community, we've had at least seven or eight HTGRs operating in the United States and in the world. So, we feel like we're ready for a commercial-scale prototype.

Our customers want to see our costs, our schedule, our licensability, before they commit to buying. They will not buy our first module. They probably would not buy our second or third.

They need some support. They probably will buy the fourth and fifth ones. So, we need to demonstrate the cost, the schedule, the licensing of our product.

So, we're ready to do that but how do you finance that? That's what we are struggling with. We can license these reactors today, at least our reactors today, with existing regulation.

It just takes a long time. We would try to modernize it so we can take advantage of the features of these advanced reactors to make the licensing more certain and remove the uncertainties. So, in our case, we are ready for a commercial-scale demonstration and we do not need any proof-of-concept-type testing that type, because that has been done.

In fact, China will start their first gas-cooling reactor at the end of this year. So, we're behind.

So, we need to catch up with them if we want to compete with them in the commercial world. That's what most of our companies are in here for, to compete in the commercial world.

CHAIRMAN SVINICKI: Okay, thank you. I'm over my time. Commissioner Baranwal?

COMMISSIONER BARAN: I think it's a really interesting topic so I'll just pick up right where you left off.

Does DOE have any current plans to construct or provide for the construction of a prototype or demonstration Non-Light-Water Reactor?

DR. HERCZEG: Our facilities are available to any and all that want to build on the DOE site. There has been some discussion and I think a site has been issued or at least a site permit for the Terrestrial reactor design.

As we go forward, I'm sure there's more that we'll put forward as they come to us. I don't know, some cases, you can do demonstrations without fissile material in it.

For example, a molten-salt reactor that Southern is working on could be actually a small loop without physical material and they wouldn't have to necessarily do that on a DOE site because there's no fissile material.

If there's fissile material, then they have to do it on our site for security and control purposes.

COMMISSIONER BARAN: As was previously mentioned, there's been a long history of these type of prototype and demonstration reactors. How does that traditionally work with DOE?

Is it basically you're providing a facility and then the vendor is constructing it all and doing all the rest of the work or is it more nuanced than that?

DR. HERCZEG: Well, I would say in the past, it would be the U.S. Government of the 52 reactors paying for the bulk of it and doing all the tests.

Today, we have what are called cooperative agreements called CRADAs, which we put in place with the Idaho National Laboratory or any other laboratory that is in a system that can handle that type of activity. Now, those CRADAs are guided by certain laws.

The Energy Policy Act of 2005 says that if we are to engage with a vendor for actual demonstration, then we must do at least a 50-50 cost share.

And we are only permitted to do up to a 50-50 cost share if it's just some experimental design such as the work that Rita does under GAIN. And that's an 80-20 split, where we pay 80 and the vendor would pay 20.

So, we're constrained by certain laws today but I will say that, and if I may go back to a little bit to the Chairman's question about facilities and reactors in the past, I think we're a lot smarter today. We know how to do smaller experiments to give us the information that we need.

I chair the Nuclear Science Committee at the OECD NEA and as part of that, we are starting a new program on facilities and advanced data collection.

We're trying to enter into the big data realm of activities, but when we do our experiments, we're really collecting a huge amount of data, hopefully. And we'll be able to have insight that we didn't have before.

One of my goals would be for the MOOSE-BISON set to be able to collect real-time data in our virtual test reactor for fuels as we go forward. And we'll be able to gain insight as to fission product production, cracking, thermal conductivity as a function of time.

And that will give us even more insight, so we cannot build a reactor ourselves but I think we're smart enough now that we can home in and focus, treat experiments, for example.

Right now, the transient test facility is actually going to be -- we have outlined a number of experiments that we're going to do but they're going to be very focused experiments to collect a lot of data.

COMMISSIONER BARAN: This may be a hard question to answer in the abstract or this early in the process, but are you envisioning that NRC would have a licensing or oversight role on any of these demonstration or prototype reactors that are being contemplated or potentially provided for?

DR. HERCZEG: I certainly would hope so. I would think it's in the best interest of the particular company going forward to license it with NRC on our site.

We can provide a license demonstration but I think if they want to be commercialized, the right thing to do is to start from the very beginning to start looking at the licensing process.

COMMISSIONER BARAN: In terms of the data from the legacy reactors, you talked a little bit about the efforts there to developed a modern pedigree for that and validate the data.

How far along are you in discussions with the Staff, DOE, or vendors about what the Staff would need and expect in terms of data quality and validation for our current modern-day licensing purposes?

DR. DEWITTE: I'll start with that.

So, we've been engaged with the Staff on this specific issue, getting back to December of 2016, where we had a public and private meeting related to some of that information.

One of the challenges was that data getting into a usable, approachable format I would say.

To say this loosely, there are boxes and boxes and boxes of this data and it's been digitized and now it's been put into a usable and searchable database.

And so we've engaged with Staff on that front.

That was also in subsequent meetings for preparing at the Fast Reactor Working Group level. We've prepared a general White Paper that we'll be sharing or submitting to the Staff.

It's just a generic overview of what the information is and how the fuel behaves, collected from some of that information.

And then I know some vendors are pursuing more specifically basically a technical report structure to say here's an introduction to what these reports look like and here's the plans which we're pursuing or undertaking to show quality equivalence. In terms of the actual work going on with that, we have been doing some of that work to date separately to kind of pilot what that looks like with the National Labs, and then we'll be scaling that and ramping that as appropriate if we make sure we work through the kinks to understand what that really looks like.

The key thing here is these databases have a large amount of data on them. They're very rigorously maintained, the records are actually quite thorough across the board.

It was very enlightening to be able to see this, but because there's so much data, actually consolidating it, penetrating it and kind of growing that database are our difficult challenges that just take time and effort and hard work to do.

DR. SHAHROKHI: For us, legacy data is the basis of our knowledge, both the knowledge that we have in manufacturing TRISO fuel in the United States and internationally.

So, that legacy data is the basis for development of our fuel, which is UCO-based. We believe this UCO-based fuel is the ultimate TRISO particle fuel.

We developed that back in the late 1990s and 2000s, and so that fuel form is being qualified as we speak and I think it has NQA1 qualification and we use the legacy data to develop that fuel. And we are qualifying it as that.

COMMISSIONER BARAN: More broadly, not specific to any one category of technology, it seems like fuel development and qualification may be the long pole in the tent for some of the designs.

I guess the challenge being that the fuel is expected, in most cases, to be very different from the fuel that's previously been qualified and used in the existing fleet for Light-Water-Reactor reactors. As was discussed earlier, many of the advanced reactor designs contemplate using fuels with enrichment levels between 5 and 20 percent, whereas, the existing fleet is all below 5 percent.

My understanding is that there's currently very little data on criticality for fuels with enrichment levels between 5 and 20 percent. Is that right?

DR. SHAHROKHI: That's correct. And benchmarking is an issue for a high-assay LEU, so low-enriched uranium.

So, benchmarking work is important and that's something that the industry cannot do and hopefully, DOE will pick that up.

COMMISSIONER BARAN: What is the current thinking on that question of who would gather the data that would be necessary for criticality of benchmarking? Does the DOE have thoughts about that?

DR. HERCZEG: I would say we would look forward to a vendor coming forward and saying I am going to build this particular reactor and here's my enrichment and we'll work on solving that particular problem at that point in time.

We've had a lot of experience with Fort Saint Vrain, which was using 93 percent. So, we know a little bit about that particular reactor and that was TRISO fuel, too.

There are more problems associated with the high-assay

LEU than just the criticality of using it within the reactor. Also, we do not have transport casks for that fuel at this point in time.

So, if the design transport casks that meet your standards -- we have to put facilities together that can manufacture and store this fuel.

So, we're at the beginning stages of this right now and I know this is a very important area because almost all of the companies have high-assay LEU 19.75.

But I think as we move forward, the earliest ones will focus on and solve that particular issue. We've been talking to enrichers about do you move UF-6 gas or do you make it to a metal and transport that, right?

The enrichers will tell you that they want to move UF-6 because it's easier for them. So, we'll design a cask for that.

Well, you only have so many dollars and you have to figure out where you're going to spend your money. So, I would look at the first movers to tell us what to do.

COMMISSIONER BARAN: And we're running out of time, but that's kind of a very interesting question at least in my mind about how you balance all that.

Because it's challenging and it's similar to the balancing we have to do in terms of how do we deploy our resources to make sure we're ready for applications that come in the door.

What are you looking at to trigger, okay, this is far enough along that we are going to start focusing on some of these trickier fuel issues for a particular design or category of designs?

DR. HERCZEG: I would say at this point in time, there's two that come to mind. One is TRISO fuel because we've been doing a lot of testing of that fuel, that's one. The other one are the micro-reactors.

There is a lot of discussion on moving forward very quickly with micro-reactors and it's being driven by mostly the Defense Department at this particular point in time.

But as we go forward with that, that will have 19.75 in it and we'll have to address those issues as we go forward with it.

So, first you identify which is a first mover and then identify, if we're going to build this particular technology, we must immediately start working on shipping casks to transport that fuel to the site, because they're certainly not going to ship a reactor, well, I hope we wouldn't ship a reactor, with the fuel in it.

DR. DEWITTE: I just have one point on that.

I think one important point on that criticality data that's particularly relevant is for the shipping and the fuel cycle infrastructure pieces. In the reactor side, there is sufficient data and you can build enough margin to make sure what you're doing with that to accommodate that there might be lags in data.

Also advances in modeling computational capabilities that have been driven through DOE outside of just the reactor complex but also into the weapons complex. It carries over here with some value.

And I think for fuel performance and how it behaves, enrichment actually doesn't affect that in terms of the fuel performance issues.

That's really a function of chemical composition, so whether it's solid or liquid, and also burn-up, so the actual amount of energy per kilogram generated.

COMMISSIONER BARAN: Thank you.

CHAIRMAN SVINICKI: Well, if my colleagues feel the same as me, like every answer is so interesting that it could bring five more questions but we will not keep you here doing that.

Again, I thank each of you for participating in today's meeting.

We will take a short break and I got hung up on our clocks being wrong last time so we will reconvene at 10:35 a.m. and give ourselves a little bit of time to have a short break here while we reset for the NRC Staff.

Thank you again.

(Whereupon, the above-entitled matter went off the record at 10:27 a.m. and returned at 10:35 a.m.)

CHAIRMAN SVINICKI: If I can please ask the attendees to retake their seats. And we are not joined by our NRC panel of presenters. So the room is quieting down slowly and people are -- okay, that -- all the sudden it quieted down really quickly once I said that. We will begin with our executive director for operations, Mr. Victor McCree, to lead off the staff's presentation. Victor, please proceed.

MR. McCREE: Thank you. Good morning, Chairman, and Commissioners. We are pleased to be here to discuss our ongoing efforts to prepare effectively and efficiently, regulate and license advanced reactors and thereby enable the safe and secure use of nuclear materials. On January 25th we provided the Commission with an overview of the new reactor's business line, of which advanced reactors is one part. On that same day we forwarded SECY-18-0011, entitled Advanced Reactors Program Status, which provided a status of our advanced reactors activities, including the progress and path forward on each of the implementation action plan strategies, and the various external factors influencing the preparation for possible licensing and deployment of advanced reactors. In today's briefing, we will provide more detail on our activities to prepare license and regulate advanced reactors, as well as potential policy issues.

Our preparedness activities have benefitted significantly from engagement with a broad range of external stakeholders. The earlier panel represents one segment of our stakeholders, and we appreciate their collaborative engagement and the value of their continued contributions. We continue to encourage productive discussions with our stakeholders as we enhance our regulatory infrastructure. And with that in mind, I and my senior leadership team meet with our Department of Energy counterparts on a quarterly basis to ensure alignment on strategic issues that affect the safe and secure use of nuclear materials. We held our most recent quarterly meeting earlier this month and discussed our respective activities associated with advanced reactors.

Also want to highlight the importance that we place in appropriate planning and budgeting for advanced reactors, particularly given the uncertainty associated with application submissions and the associated schedules. Next slide, please -- slide two. I would note that our advanced reactors preparedness activities represent an agency-level effort that is led by the Office of New Reactors. Multiple offices are engaged in new reactors, including the Offices of Nuclear Regulatory Research, the Office of Nuclear Material Safety and Safeguards, the Office of Nuclear Security and Incident Response, the Office of Nuclear Reactor Regulation, the Office of the Chief Human Capital Officer and the Office of the General Counsel.

This cross-coordination of support that we've cultivated has been vital to our efforts as many of the skill sets and experience basis needed to prepare for advanced reactors exists within the agency in different organizations.

We are leveraging those resources as well as those of the Department of Energy laboratories. In addition, we are actively engaged with the Commission's Advisory Committee on Reactor Safeguards. Today's briefing will be provided by Fred Brown to my right, the acting director of the Office of New Reactors, who will address our overall efforts and priorities. John Monninger to Fred's right, the director of the Division of Safety Systems, Risk Assessment, and Advanced Reactors in the Office of New Reactors. John will discuss -- John will address reactors licensing, readiness, and potential policy issues. Steve Bajorek, to my far left, the senior level advisor for thermal hydraulics in the Office of Nuclear Regulatory Research, will address efforts to assess and update analytical codes, tools and industry standards for advanced reactors. And finally, Brian Smith, to my immediate left, the deputy director of the Office of Nuclear Material, Safety and Safeguards, Division of Fuel Cycle Safety, Safeguards and Environmental Review will address fuel cycle considerations for advanced reactors. I will now turn the presentation over to Fred. Next slide, please.

MR. BROWN: Thank you, Vic. Good morning, Chairman and Commissioners. One of the pleasant surprises in my return to the Office of New Reactors has been the progress that's been made in the area of advanced reactors over the last several years. Notwithstanding that progress, however, there are still much that we need to do in order to be able to be fully prepared for all potential types and sizes of advanced reactors being discussed. Next slide, please.

This slide illustrates the wide range of advanced reactors under development -- a large and diverse landscape with thermal outputs that range from less than a megawatt to thousands of megawatts. It's a slightly different grouping of the technologies compared to the working groups that you heard from in the first panel this morning, and there are other advanced reactor developers that are not shown here. The six designs shown in red have responded to our regulatory information summary request for information on potential applicants, and we expect to receive more responses. Next slide, please.

As John described to you in the January Commission meeting on the new reactor business line, we have developed a vision and strategy for advanced reactor reviews. This includes near-term, mid-term, and longer-term implementation action plans that will prepare us to efficiently review advanced reactors in the mid-2020s, consistent with the Department of Energy and Nuclear Energy Institute goals for 2030's deployment that you heard from the previous panel. We are now implementing the implementation action plans and continue to make progress, including in the area of policy proposal, within the constraints of the available resources. John, Steve, and Brian will discuss our progress in more detail. In addition to what they will cover, I think it is worthwhile to note the use of the dedicated core team concept for engagement with potential applicants. We think that this organizational approach shows great promise. Next slide, please.

As you know, we expect to receive applications for advanced reactors within the next couple of years, which is well in advance of the mid-2020s time frame that the implementation action plans were developed around. To the extent that the maturity of a specific design and market niche support early applications, we should be ready to perform those reviews in as effective and efficient a manner as possible. As our confidence increases in the specific timeline for near-term applications, we will need to shape and prioritize some of the activities within the broad technology-inclusive implementation action plans.

We believe that resolution of policy issues will be key to the effective review of early applications, and that policy area will remain our highest priority. For other areas, such as skills development and computational code development, we will ensure that we are capable of addressing the earlier applications prior to doing preparatory work for other technologies. I expect to work with partner offices to develop applicant-specific integrated program plans as soon as we have solid application commitments and sufficient information to develop such plans. The strategic workforce planning process gives us the structure to plan for and meet our skills needs. The level of off-fee based budgetary support that we received for advanced reactors in Fiscal Year 2018 increases our ability to do both design-specific and technology-inclusive preparation. Steady budgetary support will be very helpful to us in meeting the need within both the near term and longer term.

With respect to the existing regulatory structures of 10 CFR Part 50 and Part 52, we believe that they offer flexibility, but not necessarily efficiency. While we have said many times that we can review advanced reactors using the existing regulations, we have also been clear regarding the inefficiency associated with a large number of exemptions. If the resources were available, particularly off-fee based resources, I believe that revising our regulatory requirements to more clearly align with the wide spectrum of potential technologies and uses in a risk-informed and performance-based manner, would significantly increase our review efficiency. It will also be important for us to incorporate the Commission's direction to use risk-informed, design-specific review standards for small modular reactors into our approach for advanced reactor reviews. Along these lines, we have been closely engaged with the Transformation Team, and we support the recommendations that you will see in the next few weeks. Next slide, please. I will now turn the presentation over to John.

MR. MONNINGER: Thank you, Fred. And good morning, Chairman and Commissioners. My remarks will focus on efforts to improve our licensing readiness and identify potential policy issues. NRC's regulatory framework is predominantly light water-centric, which presents challenges for advanced reactors. As a result, we are addressing those challenges and modifying our licensing framework to address the unique attributes of advanced reactors. We are also focused on developing options for the Commission on the resolution of policy issues to provide clarity and predictability to advanced reactor designers to that they can make informed and timely decisions. Next slide, please.

This slide illustrates the six strategies we are working on in the near term to improve our regulatory framework. We are making progress in all six strategies. My presentation will focus on strategy three, entitled Flexible Review Processes, and strategy five entitled Technology-Inclusive Policy Issues. Following my remarks, Steve Bajorek will address strategies two and four. Brian Smith will discuss fuel cycle considerations for advanced reactors, which supports strategies three and five. We had originally categorized fuel cycle considerations as mid-term issues to be addressed. However, due to stakeholder feedback, we have accelerated our efforts in that regard. This reflects our flexibility in addressing issues important to advanced reactor designers. Next slide, please.

The NRC is proactively modernizing our regulatory framework. Last December we issued guidance that describes NRC's flexible, staged and predictable review processes, which support a wide range in design, development, and deployment strategies. This got in -- to assist both designers and applicants in the preparation of regulatory engagement plans. Since the issuance, we've received positive feedback on it, and we are now considering whether additional guidance is needed for any of the specific processes within that document.

Earlier this month, as you heard today, we issued Regulatory Guide 1.232 entitled Guidance for Developing Principal Design Criteria for Non-Light Water Reactors. This -- this document describes how the general design criteria in Appendix A to Part 50 could be adopted for advanced reactors to develop principal design criteria. The Reg Guide also provides guidance for two specific design concepts including sodium-cooled fast reactors and modular high-temperature gas-cooled reactors. Going forward we are evaluating piloting this guidance to gather lessons learned. Additionally, we are evaluating industry-proposed guidance on a technology-inclusive, risk-informed, and performance-based approach. Supporting that, we completed the review of four industry-wide papers including one, the identification of licensing basis events; two, probabilistic risk assessment approaches; three, the safety classification of structures, systems and components; and four, defense in depth. Collectively, these four white papers address critical aspects of designing and licensing any nuclear power plant. Last month, industry submitted a consolidated draft guidance document to the NRC for review and potential endorsement. As the staff reviews this document, we will inform the Commission of any policy issues that arise. Next slide, please.

We are also focused on identifying and providing recommendations on policy issues. Resolution of policy issues in a timely manner is important, as it allows reactor developers to optimize their design to meet NRC's safety and security requirements. This slide lists three examples of policy issues that the staff is currently evaluating. The first issue involves emergency preparedness. In 2016 the Commission approved the staff's rulemaking plan to modify the emergency preparedness requirements. And the staff subsequently issued the regulatory basis last November. The staff concluded in the regulatory basis that there is sufficient justification to proceed with rulemaking, to develop a clear set of rules and guidance for emergency preparedness based on the perceived reduced risk of these facilities. We are evaluating using a scalable, dose-based, and consequence-oriented approach to determine the appropriate size of an emergency planning zone. We are on schedule to provide the Commission with the proposed rulemaking package this fall.

The second issue involves consequence-based -- consequence-based physical security. In 2016 the industry submitted a white paper on proposed physical security requirements for advanced reactors. The paper proposes an approach to security that considers the potential enhanced safety and security incorporated into advanced reactor designs. We have evaluated that paper and are developing options and a recommendation for the Commission's decision. We expect to provide that paper to the Commission this year.

The third issue involves functional containment. The containment building at a typical light water reactor serves many functions, such as protecting safety-related systems, structures, and components from external hazards such as tornadoes. In addition, it serves to confine radioactive material following hypothetical accidents. Reactor developers may develop other effective means to control the release of radioactive material following an accident. As an example, a functional containment consisting of multiple barriers, both internal and/or external to the reactor and its cooling system, to control the release of radioactive material, has been proposed for high-temperature gas reactors. We have developed a draft way paper -- we have developed a draft paper discussing this issue and engaged with external stakeholders over the past six months. We also brief ACRS earlier this month and will provide the Commission with a paper later this year. Overall, in addressing these various potential policy issues, the staff is demonstrating that it is receptive to changing our traditional ways to which safety and security has been achieved. Next slide, please.

The staff continues to identify and assess other issues that may contain policy issues -- or policy matters. Listed here are two issues, including siting and insurance that we are currently evaluating and engaging with stakeholders. Regarding -- regarding siting, the staff provided the Commission with several SECY papers over the years addressing source term, accident dose calculations and siting for advanced reactors and small modular reactors. Advanced reactor designers have indicated an interest in increased flexibility for siting nuclear power plants. Assuming demonstration of an enhanced level of safety and reduced accident consequences, and advanced reactor could be sited with a reduced distance to exclusionary boundaries and low-population zones, as well as increased proximity to population centers. Last November we developed a draft white paper summarizing our assessment of the current siting requirements, Commission policy and staff guidance, and issued it to facilitate discussions with external stakeholders. We will consider insights from these discussions and determine whether clarification to siting guidance, or any other actions, would be beneficial and report to the Commission on proposed actions, if any. In accordance with the Price-Anderson Act, the NRC will prepare a Commission SECY paper and supporting report to Congress recommending the need for continuation or modification of any of the provisions of the Price-Anderson Act by December 2021. Any changes that may be needed for advanced reactors would be addressed by the staff in that paper. We will continue to raise policy issues to the Commission early for awareness and resolution, including any technology-specific policy issues. I will turn the presentation over to Steve. Next slide, please.

MR. BAJOREK: Thank you, John. And good morning. I am Steve Bajorek from the Office of Research and I appreciate the opportunity to brief you on our technical readiness activities. As John stated, we have been working on six strategies to prepare for non-LWRs. The Office of Research is most involved in strategies two and four, which are directed at the development of an analysis capability for non-LWRs, obtaining the experimental information needed for code assessment, and the evaluation of material performance. Next slide, please.

Because most of our experience has been with light water reactors, a major activity in 2017 has been the familiarization with non-LWR designs and issues affecting modeling and simulation of accidents scenarios. Several staff have received training in molten salt reactors, which is probably the technology we are the least familiar with. And we have attended several workshops held by the DOE technology working groups in order to better understand those design types.

The NRC codes for accident analysis have been developed primarily for light water reactors. So we have worked to obtain access to several codes developed by DOE, and are currently evaluating those codes for our use in non-LWR confirmatory analysis. The NRC codes do, in fact, have some non-LWR capabilities. Our international code development of activities have provided us with some of those necessary code improvements for non-LWRS, and we are reviewing those contributions. With our initial considerations of the DOE codes and existing NRC capabilities, we are now trying to identify the technical gaps in code capability, verification and validation, and in materials behavior the future work must address. Next slide, please.

Selection of analysis codes for additional development and application to non-LWRs inherently involves five questions. First, does the code contain the correct physics and can it model the various design features we expect to encounter? That is, can the code model the phenomena associated with alternative coolants, a fast neutron spectrum, or a reactor cavity cooling system, for example? Second, as I mentioned on the previous slide, we are considering alternative approaches. If an NRC code is not well-suited for an application, can we use a DOE, commercial or international analysis code instead? Can we reduce costs by using a non-NRC code, keeping in mind that becoming expert in use of a non-NRC tool also incurs its own costs?

Third, if we use non-NRC codes, can we -- or must we maintain independence, especially if an applicant chooses to use those same codes? Fourth, how can we make best use of limited staff and budget? There are a limited number of staff skilled at using these complex tools. Having codes that can be used for multiple design types can enhance the efficient use of NRC resources. And finally, how extensive is the existing code verification and validation, V&V, also called code assessment? We know there remains much V&V to do. However, starting from a code that has experience with a particular design is a significant time saver. Next slide, please.

Following our initial review of DOE and NRC codes, we are proposing to use the set of codes shown in this figure for non-LWR modeling and simulation. The phenomena and accident scenarios are expected to require a multi-physics coupling of codes because of the feedback between thermal fluids, neutronics, and fuel performance. One tool developed by DOE, called MOOSE, appears to be well suited to perform this coupling. Several other DOE codes already work with this so-called MOOSE environment to efficiently pass information from one code to the other. We have coupled the NRC's TRACE code so that it can be used interoperably with these other DOE codes. I will not go into the details and description of the individual analysis codes. Some are NRC codes and some are DOE codes. The DOE codes shown here have capabilities needed for pebble bed gas-cooled reactors, TRISO fuel, sodium and liquid metal reactors that may be difficult to add to our codes. The codes in this figure cover the technical disciplines of fuel performance, thermal hydraulics, neutronics, and computational fluid dynamics. There are some duplicative capabilities at this point to allow us flexibility and options in the case of development problems. We have signed Memoranda of Understanding with DOE to obtain access and assistance to use and develop these codes, and have started to work with the DOE code experts to identify issues and resolve problems. Next slide, please.

Now, there are a number of challenges to development of a common tool set for non-LWRs. First, because of the large number of designs, it is difficult to make significant progress in any one particular design. We are confident, however, that we can refocus efforts to meet the licensing schedules of any of the near-term applications. There are numerous technical issues for which experimental data -- vital data -- does not yet exist. For some molten salts basic properties like viscosity or thermal conductivity are not known to sufficient accuracy. Behavior or materials -- creep, corrosion rate -- at the high temperatures expected in these designs is not known. And these are just a couple of examples.

The DOE codes are promising. However, there are significant challenges. DOE and NRC develop codes for different purposes. In general, the DOE codes model a system with a high amount of detail to examine normal operation. This enhances economics and is very important to industry. The NRC, on the other hand, develops codes to simulate transients and accident scenarios that drive a system to its extreme limits. The DOE codes execute on high-performance computing systems, sometimes with tens, hundreds of thousands of computer cores, CPUs.

The NRC does not have such a high-performance computing system. Currently, we cannot remotely access the DOE computers because of NRC security restrictions. But we are working on a solution. Next slide, please.

Industrial codes and standards refer to specifications and recommended practices that are used in all aspects of construction, fabrication, manufacturing, and inspection. Of particular interest for non-LWRs is that of high-temperature materials performance. Many of the non-LWR designs propose to operate at high temperatures, 500 degrees C or higher. Our initial work has found there to be limited high-temperature creep data for structural alloys at these high temperatures, and limited data for irradiation performance. Conventional industrial standards are not necessarily applicable to these new designs.

To prepare the agency for non-LWR review, staff has been active participants on several ANS and ASME committees and expert working groups. This includes the ASME Committee for High-Temperature Materials and groups developing consensus safety standards. Next slide, please.

We intend to continue to work with DOE to ensure the DOE and NRC codes can be smoothly and efficiently coupled so that a multi-physics code environment is attained. We will continue our participation at ASME and ANS codes and standards activities. We expect this to assist our reviews of high-temperature materials for non-LWRs. And of course, we will adjust our priorities to meet the licensing schedules and needs of potential applicants. Thank you for your attention. Our next speaker is Brian Smith from NMSS. Next slide, please.

MR. SMITH: Good morning, Chairman, Commissioners.

My division has the lead for integrating NMSS expertise into the NRC's efforts to plan for and conduct regulatory reviews of advanced reactors with emphasis on the advanced reactor fuel cycles, transportation, and waste management activities. Next slide, please. NMSS is an active member of the Advanced Reactors Core Team, and staff have participated in meetings with several reactor developers. We have focused on understanding the fuel cycle and waste management system necessary for each of the reactor designs. The meetings with the reactor developers to date have focused primarily on the reactor designs. However, there is some, but limited, information including fuel material preparation, fuel fabrication, nuclear material transportation, and post-irradiation fuel management, which can be either processing or storage.

We have also supported NRO in its periodic advanced reactor stakeholder meetings with the industry and the Department of Energy, and assisted in updating the policy issues table it has used to support these meetings. We also presented during the advanced reactor setting at the Regulatory Information Conference. To further knowledge in the advanced reactor designs, staff have also participated in molten salt reactor training provided by the Oak Ridge National Laboratory. We were also involved with reviewing NEI's white paper entitled "Addressing the Challenges with Establishing the Infrastructure for the front-end of the fuel cycle for advanced reactors. This paper identified a number of issues that need resolution in both the regulatory and industrial arenas. I will discuss several of these issues later in my presentation. Next slide, please.

The staff has examined the current regulatory framework and, working with limited information on advanced reactor fuel cycles, made the preliminary assessment of its flexibility to accommodate the fuel cycle and waste management systems of advanced reactors. The current regulatory system includes 10 CFR Parts 70, 71 and 72. Part 70 addresses the domestic licensing of the possession and use of special nuclear material, including requirements for an integrated safety analysis. These regulations possess sufficient flexibility to address many different types of processes and has been used to license multiple types of facilities, including enrichment, low and high enriched fuel fabrication, and mixed oxide fuel fabrication. It is also being used most recently in the construction permit applications for the molybdenum-99 medical isotope production facilities.

Part 71 addresses the packaging and transportation of radioactive material. Many different types of packages have been approved under these regulations, including Type B uranium hexafluoride, fresh reactor fuel and spent fuel. Part 72 addresses the licensing requirements for the independent storage of spent nuclear fuel, high-level radioactive waste, and reactor-related greater than Class C waste. Many different storage system designs have been approved and are use -- using these requirements. Overall, this regulatory framework appears to have adequate flexibility for solid fuel reactors operating on a once-through fuel cycle, such as for the current light water reactors or certain advanced reactor designs using solid fuel.

Regulatory guidance may need to be developed to address specific hazards that might be part of an advanced reactor fuel cycle. Examples include processing fuel with new hazards, such as metal fuel, use of special nuclear material of moderate strategic significance, or Category 2 materials, which in this case are those with higher enrichments ranging from 10 to 20 percent. These will impact safety, material control and accounting and physical security. Handling, transporting and storing fuels with these higher enrichments and long-term degradation processes for storage of fuels other than zirconium clad uranium dioxide.

Some of the advanced reactor design utilize fluid fuel, or pebbles that move in and out of the reactor. Current material control and accounting requirements for power reactors were formulated based on the current fleet of reactors with solid fuel. The staff will need to evaluate the adequacy of these requirements for these types of advanced reactors. In addition, irradiated material processing at the reactor site is possible with some advanced reactor concepts, particularly, some of the molten salt reactors. The scale and nature of irradiated material processing for these designs is not fully defined by the vendors at this time. The staff will need to further evaluate the licensing implications of irradiated material processing as these reactor designs are more fully developed. Next slide, please.

As I mentioned previously, the NEI white paper on the front-end fuel cycle infrastructure identified issues requiring consideration that focused on just the processes of producing and transporting the fresh fuel. The staff has identified some additional areas for consideration, including use and storage of the fuel. I have grouped the issues by those needed to be addressed by the industry and the staff. I will address the staff issues on the next slide.

Although not policy challenges, there are some issues the industry would need to address to facilitate the production of fuel for advanced reactors, many of which plan to use high-assay low-enriched uranium, or LEU. High-assay LEU is considered to include enrichments from 10 to 20 percent. Louisiana Energy Services is the only domestic enricher is not currently licensed to produce this level of enrichment, but could request a license amendment to do so. Similarly, the existing fuel fabrication facilities also need to request a license amendment to possess and use uranium at these enrichment levels. Alternatively, new enrichment or fuel fabrication facilities could be licensed and built. Regulations allow for the licensing of uranium enrichment facilities to produce these higher assay materials, and fuel fabricators to manufacture fuels using higher assay materials.

Transportation packages for high-assay LEU in the form of uranium hexafluoride do not currently exist in an economical form. The current cylinders are just too small. This is the form that uranium enrichers produce and ship to fuel fabricators. Similarly, new transportation packages for this type of fresh reactor fuel would also need to be developed and certified. Criticality benchmarks are used in the verification of criticality safety computer codes. There is currently a lack of these benchmarks for uranium enrichments in the high-assay LEU levels. Without these benchmarks, additional conservatism has to be added to assure there would be no inadvertent criticality. The additional conservatism could impact the design of the transportation packages, and the facilities producing and using the high-assay LEU. This could result in smaller packages and smaller processing equipment, resulting in less through-put through plant systems. Next slide, please.

From the regulatory perspective, the NRC staff has identified several areas that warrant further consideration. The staff is currently in the process of amending the regulations in Part 74 regarding nuclear material control and accounting requirements for facilities that produce or use special nuclear material, including high-assay LEU. However, these amended regulations would only include requirements for enrichments plants that produce up to 10-percent enrichment. Requirements for enrichment plants that would produce high-assay LEU could be established through rulemaking, issuance of an order or through license Commissions. Current material control and accounting regulations for fuel fabrication facilities processing high-assay LEU are sufficient. However no guidance has been published. But it is planned to be issued with the revised Part 74.

Physical protection requirements for licensees possessing high-assay LEU exist in Part 73, but have not been revised to address the increased terrorist threat after the events of 9-11. These requirements could be established through rulemaking, issuance of orders or through license conditions, as is currently being planned for licensees who produce moly-99 medical isotopes. As I discussed previously, the staff will need to evaluate the adequacy of current material control and accounting requirements for advanced reactors with liquid fuel, such as molten salt reactors. The staff will also need to closely follow the development of these reactors, as their considerations for irradiated material processing evolves. The staff will continue to evaluate these areas and will submit policy issues, such as the potential need for rulemakings, to the Commission in a timely manner. Next slide, please.

NMSS will continue to be an active participant in meetings with technology developers and future applicants. We will also support pre-application meetings, and, as appropriate, visit applicants' facilities to gain a better understanding of the details of a facility or a process. We recently made such a visit to the X-Energy pilot fuel fabrication facility. Our participation in the advanced reactor discussions has allowed us to identify actions the industry can take that will more clearly identify specific regulatory review issues for advanced reactor fuel cycle and waste management systems.

The first thing the advanced reactor designers can do is to develop their fuel cycle technology and waste management designs in parallel with their reactor designs. Early development in these areas and interaction with the staff can help identify information that might be required to support the licensing reviews. This is especially important if new fuel facilities will need to be licensed and built. The designers should also develop and submit regulatory strategy and engagement plans. Early staff understanding of the applicant's proposed regulatory strategy allows the staff to identify and discuss any difficulties associated with the proposed approach. Early identification of the timing of the regulatory interactions allows the staff to make sure that resources are available for efficient interaction. Such interaction also facilitates identification of all the issues that need to be addressed in the fuel cycle transportation and waste management regulatory reviews.

As the advanced reactor designs mature and move through the certification process, NMSS will continue to work to identify specific technical issues associated with the fuel that will have to be addressed for specific applications, and will develop guidance as necessary to address any unique issues. The longer-term accident tolerant fuel designs share some similar industry and regulatory issues with the ones previously discussed, so the lessons learned from those activities can inform how best to address these issues. Thank you, and with that, I will turn it back over to Vic.

MR. McCREE: Thank you, Brian. In closing, I want to again acknowledge the productive feedback and constructive interactions we are having with our stakeholders, both domestically and internationally. They've been of great assistance as we move forward. As you are aware, we continue to be in a period of change, as noted today, and we have already implemented a number of progressive transformational changes and are considering others. Our primary objective will continue to be to ensure that the design, construction, and operation of advanced non-light water reactors provide for the safe and secure use of nuclear materials. So with that, we welcome any comments or questions that you may have.

CHAIRMAN SVINICKI: Well, thank you to all of the panelists for their presentations and all of the NRC staff who are working on the activities you described today. I once again will begin with Commissioner Burns.

COMMISSIONER BURNS: Thank you again for the presentations. Obviously there is a broad spectrum of work that's being done in this area and needs to address both licensing standards development, research and -- you know, the front-end of the fuel cycle as well. I am going to start -- going to cover -- try to cover a few areas. I think in -- actually, it was in Fred's presentation -- said -- you said this, with respect to the existing regulatory structures of 10 CFR Part 50 and 52, we believe they offer flexibility, but not necessarily efficiency. And what I want to go to on that question -- there are two aspects when -- and we talk generally about licensing framework. One is how you do it. That's process. And what is you're trying to do? Those are the standards. So, how would you characterize where -- your state -- that statement, would you say that that's a process issue as I've described it? Or really about the standards and acceptability aspects of it?

MR. BROWN: Great question, sir. And I think it's a little bit of both, if I understood correctly. And so, in the -- in the standards clearly we've made progress with the advanced reactor design criteria for Appendix A to have a process to work through in early models, generic to high-temperature gas reactors and SMRs. But the actual execution of those is still in front of us.

And I -- and my -- and the how actually ties to some of the recent experience we've had with NuScale and the small-module or light water reactor. So, my view, I believe, is colored by the experience in attempting to work through Part 52 and some of the Part 50 reviews with the non-light water -- with the light water, the non-advanced reactors that we regularly find ourselves where we believe we can do something from a safety and security perspective that makes sense and it would be appropriate, and yet we are jumping through hoops to get there process-wise, and we're challenging ourselves for practical application of the safety case.

And so, to the extent that we have an opportunity and the funding to go back and re-examine those rules, I think applying the lessons and then tabletops of working through potential non-light water reactors should give us insights that will allow us to increase efficiency.

COMMISSIONER BURNS: Okay, and going back, again process-wise, if we look historically, we had -- we had a two-step licensing process, which got challenged. One of the few cases involving nuclear energy has reached the level of the Supreme Court, and actually challenged as a way of doing it. The court sustained it. We come -- we come into the 1980s, again I emphasize, as a reform post-TMI -- as a way of reforming licensing process after Three Mile Island to -- also to enhance standardization. We move to Part 52, which we now are -- as you well know, we are actually fully implementing for the first time, 25-plus years afterward with respect to -- as we get to the ITAAC process.

So, one of the things I think we see we've done -- which, I think is good -- in my discussion with various -- those who are potentially interested in this, there is a choice there. And actually, the -- the good old way, the Part 50 choice, may well be the one we go down. But the other thing we've had held up -- and I think, to us -- is the design -- some of the design-type reviews held another -- or processed through in other countries, particularly in Canada and the United Kingdom. While I think those examples are useful, I think they're limited. They're of limited value in some respects. But, what it comes back to -- and what I have also heard is, we -- it's -- it's sort of in there if you look at -- and I don't mean to denigrate Part 52, but in Part 52, even the 50 process, in terms of sort of -- what we -- what people are looking for is more of a staged review, or in effect, the nod that yes, that looks like okay. We're not giving you a license for that, but it looks like it's getting there.

One of the things, I think -- I've heard a critique on is greater transparency in what that nod is. What it looks like. Because we have things like the standard design approval, but topical reports other things. What is the staff doing to give a greater transparency to that? Because I think that is where there's a valuable lesson from the Canadian and the U.K. experience. John, you want to talk to that?

MR. MONNINGER: So with regards to the regulatory review framework, you mentioned the various flexible stage review processes. So we've had several discussions with external stakeholders, and we've -- we've asked them, you know, are there specific processes you would like additional guidance? For example, the SDA process. You know, do you want us to work through a tabletop on SDA? Do we need a separate guidance document on that? So we're still in those discussions now to determine, from the overall framework described in the multitude of processes, let's drill down another level, is there additional guidance needed in any of those specific areas that you -- you know, that they would like?

MR. BROWN: And if I could add on, so, specifically I think the standard design approval is a very powerful tool because it allows us to look at a significant portion of a design rather than the entirety of the design. As we execute Part 50, though, we find that Part -- excuse me, Part 52. Part 52 not only changed the traditional two-part licensing approach, but in the area of design certs, it was intended to derive standardization.

COMMISSIONER BURNS: Yes, absolutely.

MR. BROWN: And so the essentially complete design to have the finality of a design cert is powerful for where we were in 19-fill-in-the-blank when we had that experience. I don't feel that's where we are at today. So it's in no way intended to be an aspersion at either the regulatory structure or our ability to use it, but I do find on a regular basis that Margie's staff and my staff are working hand-in-hand trying to be as efficient as possible with a regulatory structure that was optimized for standardization at a time when -- when we're not -- I wouldn't say we're ready to try to standardize for SMRs or non-light water reactors.

COMMISSIONER BURNS: Okay, good. Let me change subjects. I am going to actually go to one, maybe from out in left field. I am going to Price-Anderson. So, as I recall, it's been about 20 years. I won't be around when you all have to deal with the Price-Anderson review. But I remember having to do this congressional report, I think in the late 1990s or early 2000s. But you mentioned that, John, and I want -- maybe get a little more granularity about what you're looking at in that regard with -- why is the advanced reactor developments -- why is that a potential issue within the context of that Price-Anderson report that we're obligated to develop?

MR. MONNINGER: Yes. So, over the years be it, you know, SMRs, advanced reactors, et cetera, the staff has put together lists of policy issues or lists of potential policy issues. And this is one of the issues that is out there from the previous Commission papers.

COMMISSIONER BURNS: It was, like, the 2010 paper, I think.

MR. MONNINGER: 2010 paper. And the issue there is -- there for the level 2 in -- of insurance or liability provided out there, the regulations have a power limit exclusion for power sizes greater than X, or lesser. So the question was, you know -- you know, is -- does that decision still stand? Is there anything unique with regards to advanced reactors that the staff is aware of and we should raise to the Commission's decision with regards to that level 2 of it and that power cut-off?

COMMISSIONER BURNS: Okay. Okay, and one of the things I would encourage you to -- in that regard, is one of the things that is different is that we are now, as a country, a member of an international convention on liability, the Convention on Supplementary Compensation. I don't know that that does it, but certainly -- I'd also talked to DOE on that. But I would probably also suggest looking at the other two -- well, how many -- you can count a number of -- two to three other conventions -- because, under things like the Paris Convention and the Vienna Conventions related to liability, smaller facilities are -- can wind up being treated potentially differently. And it's sort of -- it's a similar case. So I would just do that.

My last question, in terms of the international research -- and I think, Steve, or others can speak to it -- to what -- what other international research are we looking at? And obviously, we -- we are within the U.S., you know, DOE's research capabilities -- some of the other -- what other sources are we looking at that are of value to us?

MR. BAJOREK: Thank you, that's a good question because, actually if you look at the research activities in a lot of these reactors, there's been more of that going on overseas over the last 10, 15 years than there has been in the U.S. We have a couple of activities that we're participating in. One is through one of the Nuclear Energy Agency working groups where we are meeting with the other regulators and we're focusing our attention on the gas-cooled, the sodium fast and the molten salt reactors. Looking at how other regulators have been dealing with those. Looking at the database that they've been using as part of their regulations and how they've been -- they've been approaching it. A lot of that comes through the Gen-4 project. The other has been limited participation we've had with Department of Energy. It's a group called the Expert Group on Multi-Physics Experimentation, Validation and Benchmarks.

COMMISSIONER BURNS: Don't ask me to repeat that.

MR. BAJOREK: It might win you money on Jeopardy! some day if you remember all of that. But what they're doing is setting up data banks where all of the -- the nations that have collected data that's important to advanced reactors are making their contribution to that. And that's going to be a way that we may be able to gain access to data to -- for some of the -- the Russian tests that have been run.

There's a couple -- some criticality work that's important for pebble bed, for example. They would put that into the data bank and we would put in some of the data that we've taken in this country, and then everyone is going to be able to share that. So we're -- we're paying attention to it and as part of our internal task, we're trying to right now look at those technical gaps and identify, of that existing information, what is going to be most valuable to the pre-applicants that we expect to look at?

COMMISSIONER BURNS: Okay. And just to clarify, on the Generation-4 Forum, we're sort of indirect, right? Because, I mean, I used to provide legal counsel to them. So, it was -- and John Kelly from DOE was -- was there. So -- but we have some access -- was -- is that part of our cooperation with DOE and -- in terms of being able to get some information through?

MR. BAJOREK: We get a little bit of information. In fact, John Kelly was at one of the recent working group meetings.

COMMISSIONER BURNS: Okay.

MR. BAJOREK: And presented their activities, so we're using that to become more aware with the picture, correct. Our -- we haven't had direct participants in the Gen-4 project.

COMMISSIONER BURNS: Yes, thank you very much. Thank you, Chairman.

CHAIRMAN SVINICKI: Well, thank you again for your presentations. I in preparation for the meeting was reviewing -- I have not taken up before the Regulatory Review Roadmap for Non-light Water Reactors that, again, after I think receiving some comment the NRC staff published this in a, quote unquote, final form -- I am sure it will be an evolving document -- in December of 2017. But to the question about -- and I have pondered this myself, but Commissioner Burns was asking about what does a head nod or a wink, you know, precisely mean if it's not an approval? I found very interesting the discussion. The staff has defined different possible outcomes from regulatory interactions like, you can receive initial feedback from NRC. You can get a conditional staff finding. You can get a conclusive NRC staff finding and you can get a final agency position.

I felt -- I am not in the technology development community, but I thought as a whole this roadmap was a -- would have to be valuable, I would think, to technology developers who have not been engaging us in light water -- large light water reactor space -- to just get some of these foundational concepts out there, get them defined. And so, I am sure, like most things in life, it's not perfect and will undergo further evolution. And then we'll get questions about it and we can add, you know, clarifications as we move forward. But I -- I thought that was helpful. I had often pondered, short of a final agency position, what is the value or meaning of other feedback from NRC experts? And I thought this attempted to put some framework around it that was helpful.

Couple of other comments. Fred, I appreciate your acknowledgment of the promise of the core team concept. I think what strikes me is that with the diversity of technology and fuel types, the notion that we can continue to maintain a model, which I know we favor at NRC, which is as work comes in, we assign experts and it's very fluid and someone could be working on this on Tuesday and something else on Thursday. Well, the core team concept brings for us is that we cannot do the fundamental reeducation of people on the technology on Tuesday versus Thursday. So we kind of need the same person to work it on Tuesday and Thursday. And I think until there's an overall increase in our knowledge base, I think we're going to have to do this. And it limits some of our workforce flexibility that we value for other reasons. But I appreciate that we're acknowledging that here.

Also, Fred, you mentioned -- and Commissioner Burns was asking you -- about this notion of we can do this, but it won't be efficient. Boy, that has a lot of parallels with our work in the decommissioning area, doesn't it? There, we have elected to undertake a rulemaking which, while it may not benefit some of the reactors or licensees entering decommissioning of current reactors now, it would be in place for future. And there's always that question, if you never do it -- because you're always waiting, you know, it will never be in place to be of -- a benefit in the future. What's different here, though, is that -- or, what would be more challenging here about a risk-informed, performance-based framework is this diversity of technology. So, it makes it challenging, but it doesn't make it impossible. The reactors entering decommissioning encounter a lot more homogeneity of issues that allows us, I think, to more readily put in place something generic that, again, one of our objectives there is to be more efficient about it. This poses a few additional conundrums, but I -- I think the parallel exists, nonetheless.

I appreciate, Steve, your presentation on kind of code coupling -- if that's the right term -- because it is the visual depiction, your slide was, of how is it that we bridge between the unique needs of the part of the modeling that we're most interested in -- which is the kind of severe accident or systems under stress, versus operators tend to want to have greater fidelity on normal operating conditions. And you talked about suite of codes, both vendor, DOE and our codes and how we can couple. I am sure that it's an elegant graph, but I am sure we'll encounter some hiccups along the way. But I appreciate you mentioning that. I would ask you, because you touched on standards. And you mentioned having NRC participation in standards setting and standards development. That's not the end of the story, though, is it? I mean, did the presence of a staff expert on a committee -- a code committee -- is not -- or standards committee is not the be-all and end-all. Could you talk a little bit more about what needs to be done for NRC to truly accept the outcome of a standards that's set?

MR. BAJOREK: Well, I will try to address that. Although, that's not my -- my main area. I am more the -- the code guy and the thermal hydraulics. But I think what there's -- there's two areas that are very important. One has been that ASME Section 3 for the -- the high temperature materials. We want to try to make sure that we're in agreement with the standards that they're going to set -- that they have a sufficient database to cover the physical phenomena and concerns that we're going to have when we want to try to have outlet temperatures of 600, 700, 800 degrees C. It's well above, more or less, 450 or 500 degrees. And we want to make sure that that database is there. And that if we go ahead and accept what that standard is, it's consistent with the ASME boiler and pressure vessel code. And, you know, it covers the types of things that we're going to see in these new applications.

Some of the others is coming up with the -- the safety standards for each one of these technologies -- the sodium fast, the molten salts, the -- the gas-cooled reactors. And we're hoping to participate on those in sufficient amount of detail that we'll be able to take consensus and agree to it and adopt that at the NRC.

CHAIRMAN SVINICKI: To return to an area that is more familiar to you -- on the codes and the code integration and code coupling, you made a comment that the high-performance computing environments at DOE are not accessible to NRC experts because of either our security requirements, or theirs -- or maybe a combination of the handoff of the various security requirements. That sounds solvable to me, and I know that the government model is that, you know, not every agency needs to have individual high-performing platforms, but we should be able to be users on the platforms of others. What is the staff's plan to move forward and resolve that?

MR. BAJOREK: I'd say it's sort of three -- three-pronged effort right now. One, we are working with our security protocol in order to try to find a way that we can access those computers directly from headquarters. We can actually do that, but people have to go home and telework, okay? There are secure tunnels by which we can get into the --

the DOE computers. We're just not equipped right now to do that. But my understanding is they're nearing a resolution on that.

The other way of addressing that computational need is to do things more on what they call the cloud, where the computing resources are there. Okay, that's -- you get the same equivalent computing capacity, but you would be purchasing it from the cloud as opposed to accessing it from the DOE computers. The other -- and this might be the best in the long run -- is to realize that we aren't going to have to model the fidelity that they do for some of the -- the DOE work. We don't need to model every single pin. We tend to focus on the hottest assembly, the hottest rod, the hottest point in the reactor -- that type of thing. We can be less detailed.

And when you do that, it's point towards a direction where I don't need to have tens of thousands of CPUs to address that, but now we're getting back to several dozen -- maybe 100. And that's a little bit more right-sized for the type of systems that we do have access to, or could grow into the NRC. So we are looking at each of those -- those three, and I think maybe a year from now we'll be able to -- to have a better approach forward.

CHAIRMAN SVINICKI: Okay, thank you. Brian, turning to your area for a moment -- and we heard a little bit about this on the external panel. It has to do with how do we pace all of these moving pieces, but one of which is, oh, this sounds like a bad pun, but it's transportation and packaging as one of the moving pieces there. I know that this was manifested in a very real way for the staff as we looked at lead test assembly insertion. And I know this goes back to our previous meeting on accident-tolerant fuels. But, just getting materials to a location where they can be irradiated and then subsequently examined is again, one of many long poles in the tent that seem to be -- we seem to be coming up against. Is there anything that NMSS is undertaken in this area just to bring forward kind of a contemporary pacing of the things that will allow materials to be moved from one location to another? Or is it -- is it simply premature right now for NMSS to be -- oh, and we have someone coming to the microphone. Okay, please identify yourself and respond.

MR. LAYTON: Yes, good morning. I am Michael Layton. I am the division director for the Division of Spent Fuel Management. Transportation packages and storage packages are -- or, storage systems are under my division. And it's a very good question, particularly in regards to how things proceeded with the accident-tolerant fuel review. One thing that I would like to echo is what Brian said in his remarks, is that the regulations both for storage and transportation can accommodate what -- things that we're seeing in the future for advanced reactors and fuels.

What I would comment on from the standpoint of us looking back on what things that we can focus on, particularly with getting new designs or new fuels or things like that that have to be addressed within the regulatory framework -- much of what I would see as an opportunity is to have much more early outreach with industry and with fuel developers to understand what exactly they're bringing forward and how to focus the type of information that's going to be necessary for us to incorporate the -- the information into the reviews. That's very much what we've looked at thus far.

CHAIRMAN SVINICKI: Okay. You know, on that point, Fred was talking about the benefits of having core teams. Have we had NMSS expertise on the teams? Or could we add that as we think issues are going to show up?

MR. BROWN: Yes, as Brian said, we have had participation from the front end, not necessarily transportation, but that is something we need to do. And I mentioned the idea of an Integrated Program Plan that would pull together the applicant-prepared design-specific regulatory engagement plans. As they develop what their model is we would engage with them early to make sure they thought through what they need.

Some applicants may well need the fuel to be enriched in this country, built in this -- made and fabricated in this country, transported in this country before it ever gets into a reactor. Others might have a slightly different business model and it would be incumbent on us to sit down, engage with them, and lay out a Fully-Integrated Agency-Wide Program Plan for what their needs are so we make sure we don't miss anything and we've engaged in a timely way as early as possible. So very long-winded way to say yes, you are correct. We need to broaden our core team.

CHAIRMAN SVINICKI: Victor, did you want to say something?

MR. McCREE: The only thing -- so again, Chairman, great question. It's a conversation that Fred, Mike and Dan and I have had in recent weeks actually leading up to the accident-tolerant fuel briefing in recognition that this is an agency-level opportunity and that the need for, as Fred alluded to, an Integrated Program Plan perhaps slaved to each design and resourced and strategized to achieve success is the right approach.

So we're on the front end of -- the vision is clear. Now we've got to build a strategy that would produce such artifacts that would guide our development and resource allocation associated with it.

CHAIRMAN SVINICKI: Okay. Thank you for that.

Commissioner Baran?

COMMISSIONER BARAN: Thanks.

Well, thank you all for your presentations and for all the hard work that's gone into the regulatory framework for advanced reactors so far. I think you've accomplished a lot in a short period of time.

I'm going to start by asking about our preparations for near-term license applications. The fiscal year 2019 budget request includes funding to begin reviewing one advanced reactor application. Putting aside who that applicant is likely to be, what work specific to an application would need to be done to be ready to begin a review in 2019 or 2020?

MR. MONNINGER: Yes. So this John Monninger. So it's a good question.

So with regard to an application we would have to know the application. Of course you have to make sure that your staff is trained and qualified in the area. We'd have to, working with our counterparts in the Office of Research, make sure we have the appropriate codes to model that, make sure that there is either sufficient data coming in from the applicant or one way or the other that the NRC could receive the data to be able to be used in that licensing review.

So regardless of the particular design there are steps that are generic that we would need to do internally for our staff.

On a broader level a lot of the issues out there, the policy resolution issues are needed for the near-term applicants. The ARDCs which have been issued out there, they're very important for the near-term -- for potential near-term applicants. In addition, the Licensing Modernization Program that's going in -- going on, we would expect that would potentially be used also. So there are some generic activities that would be very beneficial to any near-term applicant, plus there's activities that we would need to do to prepare our staff.

COMMISSIONER BARAN: That sounds like quite a bit, not to -- I don't want to overstate the challenge, but that's a long list of things for a year that's one year or two years away from now. How would you assess our readiness to receive an application in that time frame? If something actually came through the door in late 2019 or in 2020 --

MR. MONNINGER: Yes.

COMMISSIONER BARAN: -- would we be ready for that?

MR. MONNINGER: Yes. So Fred had a very good slide out there of the various designs and the RIS responses. In terms of providing feedback on readiness, what's important to the staff is our pre-application interactions, RIS responses, et cetera. So dependent upon the particular design, we're significantly more advanced than others. The potential ones that may come in earlier, we believe that there is test data out there. Steve had mentioned the availability for NRC to shift resources to accelerate the modeling and analysis for potential ones.

So there's a broad spectrum of companies and organizations out there, and then there's a smaller set that may come in earlier. That smaller set, there's much more information on them and their much more developed testing analysis, et cetera.

MR. BROWN: And as John tries to talk around the -- who the applicant would be and the nature of potentially proprietary information, I think that it is a challenge. I think that we are as prepared as we can be given the history that we've had over the last several years of the technology-inclusive approach. I'm confident that John and his staff and Steve are well on the way to be prepared to deal with the applicant that we expect next year given the specifics.

And the reason that I talked about the tension between design-specific and technology-inclusive is I think that we need in the office to be accelerating our focus on a near-term arriver or arrivers to ensure that we are prepared and ready to be both effective and as efficient as possible.

COMMISSIONER BARAN: You talked a little bit about that in your earlier remarks. If we did get an application in 2019 or 2020, how would you balance the review work for that application with the broader advanced reactor regulatory framework work?

MR. BROWN: Yes, and so I think that any application in hand is always the highest priority for the agency. We'd establish a review schedule and work to meet that schedule. And as John was addressing, the details of the design greatly impact what that schedule looks like and the level of resources necessary. But we have constructed the budget given our workload in the entire office to be successful at what we believe is the right level of effort and we will be focusing our preparatory actions on that design in the coming months.

I think the appropriation we got this year significantly helps us do that and be prepared. And I hope that we have the stability of funding going forward to not only be prepared for the early arriver and potential other early arrivers, but also to aggressively pursue the technology-inclusive framework in its entirety.

COMMISSIONER BARAN: Okay. We talked with the first panel about the reactor physics and fuel performance data from some of the legacy reactors. How is the staff approaching that data? What do we need to do to access the data or validate the data and how big a challenge do you expect this to be?

MR. MONNINGER: Yes. So I think DOE and the various technology groups -- and Rita provided a good discussion on the efforts to collect the data, put it into databases, the searching, et cetera. What's important for the NRC is the -- is ensuring that the information is sufficiently robust to be used for the purposes for regulatory applications, for safety decisions, et cetera.

You discussed the notions of quality assurance in the '40s, '50s, '60s, etcetera, and how it's varied over the years. There are processes out there within NQA-1; and the right word is "commercial grade dedication," but you can look at data out there and run it through a process to essentially say that information is suitable for use.

So we've had several discussions with DOE. What is in I think our interest and in developers' interest is to come up with a process such that we address it generically. We don't want to adjudicate the merits of the data on Applicant A, Applicant B, Applicant C. We want to take all the DOE potential data, have a process out there that has been agreed to, and the output of that data would then be acceptable for use for any developer.

So that's been our discussions with external parties out there. Let's nail down this process such that once the data goes through this process it is acceptable for regulatory uses.

COMMISSIONER BARAN: How far along are we on getting to a process of that sort? It seems like this legacy data is going to be a pretty significant factor for a number of these designs.

MR. MONNINGER: Yes. So we're still in the discussions of that process. I think the notion of collecting the data and putting it in the databases, et cetera, is much, much more advanced than we are in terms of NRC engagement on how it when then be qualified.

MR. BROWN: I would if I could just expand on John's comment a little bit that we talk about data a monolithic -- it's all the same and it doesn't matter what the use is. And that's actually not the case, obviously.

And so as we talked about the area of criticality safety and the standards, the experimental data for enrichments between 10 and 20 percent, you can use what we've -- we can use what we've got. It's just that we then apply a level of conservatism that might not be fully beneficial to the applicants. And so they could benefit from spending the resources and taking the time to get additional data.

I think we went through this in a licensing action, not in the advanced reactor area, recently where I did a little research online, and just the concept of gravity, to use an example; has nothing to do with that we're talking about, but the concept of gravity and an equation for gravity and attraction between bodies has been around for over 300 years now. It was 200 years ago when the first reasonably accurate value for the constant g was developed at a time before computers, no nuclear QA standards, and yet even with our best technology today, while we have many more significant digits, the value we use for g is within 1.2 percent of what it was over 200 years ago.

And so as long as you're familiar with that and apply conservatism around the use of the data that's appropriate for the data that you have, the -- there's no question that the reactors that developed the data that we're looking at operated and operated safely and produced information. What we have to decide, as John was saying, is what degree of specificity or the pedigree to we assign to that data? How much margin do we -- and Dr. Lyman kind of talked around this in the first panel -- what margin do we have to establish working with Steve in the codes, in the validation of the codes and the values that will be used to have confidence that it's good enough for the reasonable assurance of adequate protection decisions that we'll need to make?

So I -- John's absolutely correct in terms of the generic process, but it's not that we have no confidence in the information. We have -- empirically there's a lot of confidence in that data. It's just how many significant digits do we give it credit for, in my view, not with -- obviously not specific to any licensing decision, but in general.

COMMISSIONER BARAN: Okay. On the first panel Ed Lyman raised a concern about the amount of information being withheld by vendors as proprietary. At least that's how I understood the concern. What does the staff think about that concern and can someone discuss how we're making determinations about what information is proprietary and what should be publicly available?

MR. MONNINGER: Yes. So the NRC's requirements out there for proprietary material and withholding of proprietary material are no difference between materials, waste, advanced reactors, new rectors, non-power, et cetera. So we follow the exact same process out there.

When an applicant submits a report, they'll include an affidavit and the logic or rationale for potentially withholding it. The staff then reviews the material and either agrees or disagrees with it.

I think one of the issues out there is there's a lot of discussion with regards to advanced reactors, but in terms of actual documents being submitted to the NRC there's actually very few. We are having a pre-application interactions with a company Oklo. They have submitted a few documents. For example, the QA topical report. It is publicly available. Other reports that they've submitted would not be, however, there would be the forwarding letter that is.

In addition to that we've had public meetings. They generally have an open portion of the public meeting. The slides are out there and then closed.

So I think one of the differences, there's a lot of talk, there's a lot of discussions out there about advanced reactors, but then the actual meetings or applications or submittals into the NRC are relatively low. So there's not a huge population of documents out there.

COMMISSIONER BARAN: Okay. Thank you.

CHAIRMAN SVINICKI: Well, again I thank you all for your presentations. Something -- feedback that I have heard about the staff's work in this area has been very complimentary of -- I'll use the term "agility," although we've been using that a lot since Project Aim. But just the ability to have an adaptive application of the frameworks, whether they be things like design reviews that again we're kind of moving away from the design certification as the only model. There's other -- the phased feedback that you all are structuring that you're available to give should someone prior to applying wants to engage the NRC.

So I hear a lot of favorable commentary, but it's so curious to me because I also receive critical commentary or concerns that we don't have one generic approach, but the technology development community seems to be very complimentary of coming in, describing how they're pacing their development and what would best be of utility to them in terms of regulatory feedback. So I don't know how we solve that conundrum. I think again technology developers are complimentary of our adaptive approaches. It's a little bit stylized depending on what they need and when they would requests that they receive it from us. So I think that there are a lot of moving parts, as Commissioner Baran mentioned, and it's a lot to keep all pacing along together just internally between the offices and then with the external community. So I appreciate all you're doing.

I walk away from this meeting feeling it is a pretty -- it's a tall challenge, but I can't really find anything that I could suggest to you that you're not thinking of or doing or keeping at the ready as something that might be of use in resolving something or giving feedback or solving something. So again, I appreciate all of the staff's hard work, not just the presenters, but all of the subject matter experts who've contributed to what you're doing today.

And I know we're keeping OGC busy as well, because the novelty of a number of these things require the technical experts to go back to their legal colleagues and receive just a fundamental confirmation that they're applying the existing requirements with the correct paradigm.

So again, thank you for that work. And if there's nothing further, then we are adjourned.

(Whereupon, the above-entitled matter went off the record at 11:54 a.m.)