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TECHNICAL SESSION - TH27

NON-POWER AND ADVANCED REACTORS: MERGING OF TWO WORLDS

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THURSDAY,

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The Technical Session met via Video-Teleconference, at 10:30 a.m. EST, Robert Taylor, Deputy Office Director for New Reactors, Office of Nuclear Reactor Regulation, presiding.

PRESENT:

ROBERT TAYLOR, Deputy Office Director for New Reactors, NRR/NRC

MARGARET ELLENSON, Senior Licensing Engineer, Kairos Power, LLC

MOLLY-KATE GAVELLO, Project Manager, NPUF Licensing Branch, Division of Advanced Reactors and Non-power Production and Utilization

Facilities, NRR/NRC

ALISON HAHN, Acting Director for Nuclear Reactor Deployment, U.S. Department of Energy

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RUSTY TOWELL, NEXT Lab Director, Abilene Christian University

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

Non-Power and Advanced Reactors: Merging of Two Worlds:

Introduction Remarks and Introductions
by Robert Taylor, Deputy Office Director for New Reactors, NRR/NRC Chair..............4

Department of Energy's goals in non-power and advanced reactors
by Alison Hahn, Acting Director for Nuclear Reactor Deployment, U.S. Department of Energy......................................10

Mission of ACU's NEXT Lab
by Rusty Towell, NEXT Lab Director, Abilene Christian University 19

Non-power and advanced reactor plans for Kairos Power
by Margaret Ellenson, Senior Licensing Engineer, Kairos Power, LLC 28

Discussion of the ongoing work at the National Reactor Innovation Center
by Brad Tomer, Chief Operating Officer, National Reactor Innovation Center, Idaho National Laboratory 35

Q&A...48

P R O C E E D I N G S

(10:30 a.m.)

MR. TAYLOR: Good morning and welcome to the work session, "Non-power and Advanced Reactors: Merging of Two Worlds." My name is Robert Taylor and I'm the Deputy Officer for the NRC Office of Nuclear Reactor Regulation and I will be the Chair of the session today.

We will be focusing on the relationship between non-power and advanced reactors with insights from designing, licensing, constructing, and operating non-power facilities are informing the development of advanced reactors. And how the technology development and licensing approaches for advanced reactors are influencing non-power facilities. This morning we will begin with a brief introduction into non-power and advanced reactors before we dive into the discussions with our speakers.

We will then begin our Q and A period. Please feel free to submit questions at any time during the session and we will address them during the Q and A period. Your questions can be directed to a specific speaker or to all speakers.

Next slide please. For our panel today, we welcome representatives with diverse perspective on both non-power and advanced reactors from industry, universities, and federal government organizations. First, we have Alison Hahn. Ms. Hahn has been with the Department of Energy's Office of Nuclear Energy since 2011. She has managed several programs including the Advanced Methods for Manufacturing and the Nuclear Science User Facilities with the Nuclear Energy Enabling Technologies Program. And most recently, the Light Water Reactor Sustainability Program.

Currently she's the Acting Director for the Nuclear Reactor Deployment, which is focused on modernizing technologies and approaches acceptable to both advanced reactors and light water reactors in supporting the deployment of a variety of advanced reactor designs. She holds a Bachelor's Degree in Nuclear Engineering from Pennsylvania State University and a Master's Degree in Environmental Engineering from Johns Hopkins University.

We will also hear from Dr. Rusty Towell. Dr. Towell is the founding Director for Abilene Christian University's Premier Research Project

called NEXT - Nuclear Energy eXperimental Testing. Rusty has a B.S. Degree in Engineering and Physics from ACU and a PhD in Nuclear Physics from the University of Texas. He served in the U.S. Navy where he rose to Lieutenant while serving as an instructor at the Naval Nuclear Power School.

Rusty completed a postdoctoral research fellowship with Los Alamos National Laboratory, working on the PHENIX Experiment at the Brookhaven National Lab. And in 2001, he joined the Physics faculty at ACU. For the past 20 years, Rusty has worked at many different national labs on several information research projects. His 250 articles and other scholarly writings have been cited more than 30,000 times by peer-review publications.

Next, we will hear from Margaret Ellenson. Ms. Ellenson has 17 years of experience in the nuclear industry and is currently a senior engineer with Kairos Power on the Licensing Team. She is responsible for licensing activities relating to structural graphite materials, material control and accounting, physical security, structural design, and instrumentation and control, including the associated content in the preliminary safety analysis

report in Hermes non-power reactor.

Before joining Kairos Power, Margaret had worked for 15 years at the Nuclear Regulatory Commission in rulemaking, vulnerability analysis, risk assessment, and material science research. Margaret earned a Master's of Science Degree from the University of California at Berkley in Material Science Engineering.

Finally, we have Brad Tomer. Ashley Finan was originally our NRIC speaker, but she had some travel come up, so we're excited to welcome Brad to the discussion. Brad Tomer is Chief Operating Officer at the National Reactor Innovation Center at the Idaho National Laboratory, managing the day to day operations of the center. Brad is applying a lean startup approach, combined with advanced engineering processes and also has learned from experience managing large energy demonstrations to accelerate the demonstration and deployment of advanced nuclear energy.

Brad has a rich history of deploying advanced technologies. Brad served as interim CEO and Vice President of Operations for Avitas Systems and Chief Engineer and General Manager of Advanced

Technology for GE Oil and Gas. Prior to GE, Brad served as Chief Operating Officer at the National Energy Technology Laboratory implementing Science and Technology programs across the Energy industry. He has a B.S. degree in Petroleum and Natural Gas Engineering from Pennsylvania State University and an MBA for George Mason University.

We're very excited to hear the presentations this morning. Next slide please. So what are we talking about when we say non-power and advanced reactors? There are many different types of facilities. What are the differences? How do we know which type we are referring to? Most people understand what a nuclear power plant is, but with smaller designs, there are many terms and they tend to overlap.

Next slide please. The NRC has successfully licensed and the Nuclear Industry has safely operated both non-power research and test reactors and large light water reactors. These technologies are the current bookends for a potential spectrum of new and advanced power and non-power reactors. The designs now being contemplated for deployment in the United States vary in power level,

cooling technology, fuel design, safety features, and operational facilities from what has been previously licensed and operated. This will require new and different thinking for how to demonstrate and assess safety.

We aren't starting totally from a blank sheet given our prior experiences. But we do need to be thoughtful to ensure we don't inappropriately bias our thinking about these new technologies or prior experiences that may not be applicable. To help us ensure that we are starting from a common point for today's presentation, I'll give you a brief introduction to a few types of facilities that we might hear about today. Full definitions of these terms can be found in the Nuclear Energy Innovation Modernization Act and Title 10 of the Code of Federal Regulations.

Advanced reactors refer to nuclear fission or fusion reactors with significant improvements compared with commercial nuclear reactors. These improvements can include additional enhanced safety features, greater fuel utilization, and enhanced reliability, among others. A research reactor is a non-power production or utilization

facility, which I will define in a moment. It is specifically licensed under 10 CFR Part 50.21, which is a specific type of license for research and development.

A testing facility is a nuclear reactor, which has a thermal power level more than 10 megawatts or for certain configurations, a thermal power more than 1 megawatt. Production facility is a facility designed and used primarily for the formation of plutonium or uranium-233 or the processing of irradiated materials containing special nuclear material. A utilization facility is almost the opposite of a production facility. They are facilities other than those designed or used primarily for the formation of plutonium or uranium-233. A non-power production or utilization facility is a broad term that means a production or utilization facility that is not a nuclear power reactor or production facility as I defined earlier.

Now that we have a bit of background on the topics to be discussed today, I'll turn it over to Alison Hahn to discuss the Department of Energy's goals in non-power and advanced reactors. Alison?

MS. HAHN: Thanks, Rob. And good

morning, everyone. Good day and likely good evening. I'm Alison -- Do we have the slides up? There we go.

Can we go to the next slide please. Okay, so we've known nuclear power to operate in a baseload capacity for decades now, but we see that changing and quickly. We need these reactors to operate flexibly with variable renewable energy sources to provide a more reliable grid, to provide heat and electricity to the carbonized industry.

The department's support of the advanced reactors through the Advanced SMR Program and our Advanced Reactor Demonstration Program is intended to provide the necessary support to vendors to successfully deploy their concept and really motivate investment for future deployments. So we're supporting these designs through the marketplace through dedicated R&D programs and competitively selective awards such as these on the side here.

So there are three first of a kind demonstrations here. I'm going to go kind of counter clockwise here. So starting in the upper left, the Carbon Free Power Project is planning to construct the first new scale commercial demonstration plant in Idaho. Moving down to the bottom left, we have the

NATRIUM reactor, a sodium-cooled fast reactor planning to be cited at a former coal site in Wyoming. And then on the bottom right there, we've got X-energy planning to site their high temperature gas reactor at a site in Washington. And these three designs will be fully commercial designs and licensed by the NRC.

And then if you continue on and make your way back to the top there in the upper right, we've got five private-public partnerships with lower maturity designs, both the Molten Chloride Fast Reactor Project and the Kairos FHR will result in smaller scale test reactors to help inform their commercial designs. ECRI will be DOE-authorized to test their design at Idaho National Labs. And I know that Margaret will speak to it, but Kairos will obtain an NRC license for a site by Oak Ridge National Lab.

And then Holtec's SMR-160 is the only light water reactor SMR in this list here. And we'll focus on early stage design, engineering, and licensing activities. And then the last two we have are both microreactors. Westinghouse's eVinci will mature a heat-pipe-cooled microreactor. And BWXT BANR reactor will mature a commercially viable

transportable microreactor design. So these and other advanced reactor designs will help to address carbonized sectors like transportation, steel, chemical production, and help us meet our clean energy goals of 100 percent clean energy sector by 2035 and a net-zero economy by 2050.

Next slide please. I mentioned the Advanced Reactor Demonstration Program or ARDP and the seven projects. But the ARDP Program really goes beyond just those private-public partnerships. These designs and all designs require support throughout their life cycles which takes us into the National Reactor Innovation Center here. NRIC again is also a part of ARDP. It's a relatively new program authorized by the Nuclear Energy Innovation Capabilities Act of 2017. And was really formally established in 2019. So their mission is to enable and accelerate the development and demonstration of advanced reactors. And it's a national program -- national DOE program, which is led by the Idaho National Laboratory and allows collaborators to harness the world class capabilities of our national laboratory system.

NRIC supports advanced reactor

developers by providing access to infrastructure, materials, and expertise. They also support other activities such as helping to reduce the regulatory risks for advanced reactors, reducing the cost for advanced reactor construction, and filling experimental gaps that are vital to advanced reactor development and deployment.

Next slide please. So NRIC is working to establish demonstration test beds that will provide the infrastructure where industry or other users can start up, test, and operate their concepts in a safe and economical manner to obtain the data that they need to support their design activities and future licensing applications.

So the first we have here, the Demonstration and Operation of Microreactor Experiments or DOME Test Bed will be capable of siting experiments that utilize DOE safeguard category 4 material such as high-assay LEU and operate at less than 10 megawatts thermal. So NRIC is working to reestablish the reactor demonstration test bed capabilities of the Experimental Breeder Reactor-II facility at the Materials and Fuel Complex at INL to support this DOME mission. The EBR-II facility

provides a unique opportunity for NRIC to leverage an existing facility that is co-located with existing support capabilities at MSC. We expect construction of DOME to be completed in our fiscal year 2023 and to enable operations in fiscal year '24.

And so NRIC is also developing a second test bed capable of siting experiments that utilize safeguards category 1 material such as high enriched uranium or plutonium and operate at 500 kilowatts thermal or less. Some of the advanced reactor concepts being developed have never been built or operated before. First of a kind nuclear technology developers need a location for testing, validating, and maturing new reactor technology to concept. And for validating the safety and workability of systems or components individually or as part of the overall reactor system.

And although not required for the commercial concept, some reactor demonstrations and experiments with higher enrichment fuel to keep the size of the reactor small, while ensuring that neutronics and thermal hydraulics are representative of their commercial designs. So this safeguard Category 1 test bed would support the safe and

economical testing and demonstration of those first of a kind reactor concepts. We are currently in the process of evaluating all options for this capability.

Next slide. So another capability under development is the Microreactor Applications, Research, Validation, and Evaluation or MARVEL for short. Will serve as a unique small scale 20 kilowatt electric nuclear test platforms supporting experimental validation activities for operating regimes and really empower end-use applications applicable to the broader microreactor community. The difference between MARVEL and those two NRIC test beds is that INL will produce and construct an operational microreactor that will produce heat and power to a functional micro-grid.

The development of the microreactor will result in lessons learned for commercial developers, but will also create momentum and champion rapid technology maturation and engage microreactor end-user (audio interference) directly. Technology developers will be able to test new microreactor technologies and will be able to evaluate systems for remote monitoring and develop autonomous control

technologies.

Next slide. So this is my last slide for today, but equally as important as all the other ones. Even with the first of a kind deployment and demonstrations across the industry, the need for a Versatile Test Reactor is so important for on the precipice of building a number of advanced reactors. But that doesn't necessary mean they are as optimized as they could be. VTR will allow us to test and validate better optimized fuels and materials to continue advancing these designs and continuing to increase their economic competitiveness.

I want to draw parallels to the role that the Advanced Test Reactor out at INL has played for the past 50 years. It has provided accelerated fuels and materials irradiation that has supported the existing commercial fleet and the U.S. Naval reactors. It is this kind of testing that has supported the commercial nuclear industry and resulted in their approving fleet wide performance for 60 percent reliability range in the early eighties to a fleet wide performance of over 90 percent today. What is missing now is the ability to support long-term innovation through the ability

to conduct accelerated neutron damage testing. And a high flux, fast spectrum neutron test reactor will allow us to conduct those tests.

Next slide please. I think that's it.

MR. TAYLOR: Alison, thank you so much. I wanted to ask a quick question here before we move on the next speaker. That presentation was phenomenal. But given the environment that we're in, how does DOE remain flexible for so many different technologies and vendors?

MS. HAHN: Right. And so many of these designs are available because of historical DOE investments. We've provided about $400 million in TRISO and graphite investments. And it's no surprise that many of the vendors are using it. Just looking at only the ARDP winners, there's four reactors using TRISO fuel. So DOE has a history of supporting technologies that support multiple concepts. We work very hard to prioritize projects to ensure we are staying relevant with multiple designs. Of course, we can't support everyone through our directed R&D programs, but that's why we utilize our GAIN Program -- the Gateway for Accelerated Innovation in Nuclear Program. And a number of other industry

support groups to help us get the pulse of industry and prioritize the work that we're doing.

MR. TAYLOR: Wonderful. Thank you for that. Now I'd like to turn it to Rusty from ACU to talk about the merging of non-power and advanced reactors at Abilene Christian University.

DR. TOWELL: Hey. Good morning. It's great to be with you. Thank you for your time and for the ability to be on this panel. It's an exciting panel where we're trying to talk about how non-power and advanced reactors merge together. And I think that what we're doing at Abilene Christian University is a great example of that. This is a melting of a university research reactor, but not traditional TRIGA. And so we're looking at advanced reactors. We're very thankful for Natura Resources being a sponsor for this research. And I'm very thankful for the chance to talk to you about it.

Next slide please. So NEXT stands for Nuclear Energy eXperimental Testing. That's what we stood up here at Abilene Christian University with the idea that this is a great way of bringing hands-on experience to a large number of students. And we're really focused on finding global solutions to the

world's critical needs.

Next slide please. And I'm sure this audience is aware of that, but it's always in my opinion worthy to remember what the goal is. Because the goal of this deployed technology is extremely lofty. We'd really like to develop an energy source that's clean and safe and really would change the standard of living of people -- billions of people around the globe. And by building advanced reactors and having access to new medical isotopes, we really have a chance to look at new treatments for cancer that have never been discussed before. So the access to medical isotopes again is something that will affect billions of people.

And finally, if we can have a safe source of high processed heat, then we can do a lot of things, including desalinate water or purify water, which is a need again around the world. So the way we think about this project and working towards a deployment that will bless the world sometime is really a driving force on this.

Next slide please. So the image on the right is our molten salt test loop that's been in operation for over three years on our campus. But

it is a great image to just remind people that the mission of our NEXT Lab is to provide global solutions to the world's need for energy, water, and medical isotopes by advancing technology of molten salt reactors while educating future leaders in nuclear engineering.

Next slide please. So the two sort of focus areas of our research, we really wanted to do research that's applicable to a lot of different designs. The first key requirement we looked at is molten salt as a coolant. Molten salt has a lot of advantages of coolant. It allows us to reach high processed temperatures while keeping the safety very -- the safety concerns very low because we never have the phase of transition to a steam. So by using a mixture of the right salts, we can have a low melting point while still having no chance splash to steam.

Next slide please. And the second key requirement that we really are focusing on is that we want to use liquid fuel in our reactor. So old solid fuel technology of course ends up with throwing away a lot of useful uranium. And so what we really want to do is we want to increase fuel utilization. We

want to decrease waste and simultaneously get access to medical isotopes and then take advantage of a design that they can't melt down. So those are our two key requirements and what we're really looking at.

Next slide please. So we're not doing this alone at ACU. We've built a research alliance that we refer to as NEXTRA or NEXT Research Alliance. And we're really thankful for our partners, the University of Texas, Texas A&M, Georgia Institute of Technology have all joined with Abilene Christian University to work towards this goal. All four universities are being sponsored by Natura Resources.

Next slide please. We meet together regularly with workshops as we're working to develop our design and then develop our licensing work. Here's a workshop from last fall where we have all four universities together. And despite what happened last year in March Madness, we worked very well together in this organization.

Next slide please. On the ACU campus, we have a wide variety of research projects. And I share this partly here just to allow you to understand what our students get their hands on. In the

left-hand column is a lot of our salt systems. At the top is our molten salt test loop. We've been operational for over three years. And we're in the final commissioning stages of our fluoride molten salt test loop, which would be a high temperature system.

We're designing the end stages of designing an order of magnitude larger system, we refer to as the molten salt system, which will allow us to both purify the salt and also work with larger quantities of salt and incorporate elements of design from our reactor, including heat exchanges and other components. But the second column is really a lot of chemistry work. And a lot of people refer to molten salt reactors as chemistry reactors. And so how do you remove impurities? How do you purify the salt? How do you know what the salt content is as its changing? And so we have projects stood up to work on all those things.

The third column is support that expands across a lot of our systems, instrumentation development, data acquisition systems, and filtering of the salt. And the final column is individual component testing. And the bottom right images are

molten salt research reactor, which is really the reactor that we're working to build. And we're in the process of pre-license engagement with the NRC to talk about now. Everything on here with a star has some patented work or patent-pending work on it. And so we're really trying to collect the intellectual property so that we can develop this and deploy this commercially.

Next slide please. We're building our reactor design. We're leveraging heavily off of the molten salt reactor experiment. This was the reactor that was built and operated Oak Ridge National Lab in 1960s. It operated for four years. What we've done is we tried to scale down from that. And so as we think about the reactor we're building, we're building a reactor that's easier to design than -- easier to design, build, and get licensed hopefully than the 1960s. Of course in the sixties, it didn't have to go to the NRC, but we're working on a design that uses Oak Ridge fuel that has a lower power density and doesn't have the main safety concern of the water and salt mixing. And so we're not having any water in our reactor enclosure.

Next slide please. We are though however

modeling a lot of our work off of the MSRE. So our design is in the top. Our little conceptual cartoon; a reactor enclosure in the center, fuel handling on the left, secondary heat removal on the right. That mimics a lot of what was done by the molten salt reactor experiment in the sixties.

Next slide please. So just -- Rob touched on this at the beginning. What is a university research reactor? And how is it different than test reactors or other power producing reactor that we will hear about in this session also? ACU plans to pursue this 104c designation of being a research reactor. And I guess for the sake of time, I'll skip on to the next slide.

We are working here at Abilene Christian University to build a building to house this reactor using the 10 CFR 50.10 exemption that allows us to build a reactor in a pre-existing building. We actually designed last year. We have just broken ground this year on the facility that we're referring to as our Science and Engineering Research Center. This is a multi-use facility that has some unique capabilities that will be ideal for siting university research reactor. I expect the completion date as

the middle of the year next year in 2023.

Next slide please. This is a -- This image is a much more interesting image in my opinion of the building. On the left, you see some specialized labs that support the reactor and the reactor design and work. But the really exciting part is the high bay -- research bay on the right. It's a very large room with a 40-ton crane over the top. Its main feature is the trench on the bottom.

If you go to the next slide, it should show us some dimensions. The trench is 25 feet deep, 15 feet wide, and 80 feet long in this 6,000 square foot room. And so that trench in the middle of this high bay research area is an ideal place to drop in a research reactor, put a concrete shielding on the top, and you have a safe place to rapidly deploy and test a research reactor and advanced reactor at a university.

Next slide please. And so I can't stop without thanking the support we have. We've been supported from Excelsior Foundation, Department of Energy through GAIN grants, and NEUP grants. The Development Corporation of Abilene is sponsoring our work. And of course our primary sponsor is Natura

Resources. Thank you for your time. I appreciate it. I'll be glad to take your questions.

MR. TAYLOR: Thanks, Rusty. I really appreciate that thorough assessment of what ACU is doing. I think research is an essential piece of developing and deploying in that generation of reactors. So what do you see as the most critical attributes of university research that can facilitate and expand the development and deployment of these new technologies?

DR. TOWELL: As mentioned in the last talk, molten salt reactors are a little lower technical readiness level than some of the other technologies that have been deployed multiple times. I mean we have this great example of the MSRE in the sixties at Oak Ridge, but there are lots of areas where we really need to advance the technical readiness level. So everything from flanges to pumps, seals, valves, flow meters, all those really need to be advanced so that we can completely instrument a new reactor and do maintenance on. And so every one of those areas is an area where there needs to be some research.

And that's a great place for a university

to step in and help. And so as I pointed out on that one slide, there's a lot of areas where we're developing the technology. And as we solve those problems, that gives us an ability to collect that intellectual property and give a return to the industry that's investing in this advanced reactor.

MR. TAYLOR: Thank you, Rusty. I really appreciate that response. I think we will certainly get some questions for you as we go forward here.

So next, I want to turn it to Margaret Ellenson to present on non-power and advanced reactor plans for Kairos.

MS. ELLENSON: Thanks, Rob. All right, I see the slides there. Hello. My name is Margaret Ellenson. I'm a senior licensing engineer with Kairos Power. I'm grateful to have the opportunity to speak about Kairos' recent work on a non-power reactor construction permit application, as well as our advanced reactor development.

Next slide please. Kairos Power is a mission-centered organization. Our mission is to enable the world's transition to clean energy with the ultimate goal of dramatically improving people's quality of life while protecting the environment. I

was recently speaking with a friend about this slide. And they called it "the slide with all the lights". Actually the reason that this image is so powerful is that it's a reminder of how much of the globe is still dark. We as a part of the global community have important work to do to bring affordable, safe, and clean energy to the market.

Next slide please. I'll start with an introduction to Kairos Power. KP is focused on commercialization of the Kairos Power fluoride salt-cooled high-temperature reactor or KP FHR. Just this past December, we celebrated our fifth anniversary. And our staffing levels are continually growing. We're now above 250 employees, a significant portion of which is engineering staff. In addition, KP has in place strong collaboration agreements with several national laboratories.

KPs focus is on engineering design, licensing, and physical demonstration. And that last element is a key cornerstone of KPs development strategy. I'll speak to that strategy a little bit more in the next slide. Kairos' goal is for commercialization demonstration of a full KP FHR on or before 2030, while building the infrastructure for

rapid deployment during the 2030s. KP has also set cost targets for the KP FHR to be competitive with natural gas in the U.S. market. This would accomplish our mission to deploy affordable energy that is both clean and safe.

Next slide please. This slide illustrates KPs development strategy and shows how KP uses a non-power reactor as a bridge to advanced reactor deployment. Traditional nuclear focuses on the design phase of development. And Kairos is changing that paradigm by using rapid iteration with hardware, including deployment of a non-power reactor. This is the merging of the two worlds that's the subject of this panel.

Folks at Kairos like to say, "Hardware is worth a thousand calculations". And to that end, Kairos' development strategy is based on hardware iteration so that learning can be rapidly incorporated into design. Iteration is fastest in a non-nuclear environment, so KPs iterative loops include both nuclear and non-nuclear capabilities.

Several of these iterative loops are shown on this slide. So starting on the far left, you'll see the Engineering Test Unit Demonstration

Experiment, which we call ETUDE. It's a non-nuclear reg that uses simulated fluids to inform modeling capabilities. It's already been producing results for several years. Next is the engineering test unit, which we call ETU. This is also a non-nuclear unit. It will have graphite pebbles inside, which is KPs molten salt coolant. Construction is nearly complete of that unit in Albuquerque, New Mexico. And lessons learned from that ETU will be fed into the final design of Hermes.

Hermes is the next loop on this slide and you'll see it in the middle of the image. It is a non-power reactor that's a scaled version of a power reactor. And I'll talk more about the details of Hermes on the next slide. The next thing you'll see in the image is U-facility, which is also a non-nuclear, but this time full-scale unit that will allow KP to incorporate learning about operations and maintenance and maintenance before deployment at the full power KP FHR.

Can I have the next slide please? Okay, now a little bit more about the Hermes reactor. Hermes is a non-nuclear power reactor -- excuse me. Hermes is a nuclear non-power reactor -- I flipped

those two -- at approximately 30 percent scale to the full power reactor. It will use HALEU pebbles, online refueling, and FLiBe molten salt coolant. It will prove Kairos' capability to deliver a KP FHR at cost targets. Now the nuclear industry is very familiar with converting nuclear heat to electrical power. And that's why Kairos' objective for Hermes is to demonstrate low cost nuclear heat, rather than electrical generation.

By learning through the Hermes experience, Kairos will be able to incorporate lessons about manufacturing, materials, construction, and more on real hardware in ways that simulations can't support. Hermes also allows Kairos to exercise the supply chain for resources that we will need for the KP FHR. And it finally provides a complete demonstration of nuclear functions to inform operations and decision making going forward. Ultimately the Hermes iteration step allows Kairos to reduce design, supply chain, and regulatory risks while building vertical integration knowledge and capabilities.

Can I have the next slide please? Kairos Power is using the Part 50 license application

process for Hermes and expects to do the same for the first KP FHR. This is sometimes referred to as the two-step application process. KP submitted the Hermes Construction permit application to the NRC last fall and it's under review by the NRC. It may not be intuitive that going through the licensing a test reactor would reduce regulatory risks for a power reactor. What Hermes allows Kairos to do is to identify challenges to the licensing process early. Things like knowledge gaps or level of detail.

So the construction permit itself is another form of rapid iteration on the path to advanced reactor deployment. It also affords Kairos the additional opportunities for strong pre-application engagement with NRC staff. This is another example of how iterative development strategy used by Kairos Power, along with demonstration through non-power reactor units puts Kairos Power on a path to accomplish our mission, to enable the world's transition to affordable, safe, and clean energy. And Rob, that's the end of my prepared remarks.

MR. TAYLOR: Thank you, Margaret. You

touched on what I wanted to ask you about here in the presentation. So I'm going to ask you maybe just to elaborate a little bit. It's been a while since the last application for research and test reactor license was submitted to the NRC. What specifically is driving the interest in RTRs now for advanced reactor developers.

MS. ELLENSON: Yeah. Yeah, it has been a while. So in recent decades, the landscape for reactor development has shifted. There's a renewed support for using all the different tools available to mitigate the effects of climate change. And data shows that nuclear power is a key component of our clean energy future.

So there's a variety of different technologies that are being developed right now; microreactors, space reactors, advanced reactors, all sorts of things. So a non-power reactor application can be a useful development tool for both the developer and the NRC staff for new technologies. It also happens to fit well into the rapid iteration strategy that Kairos is using.

MR. TAYLOR: Thank you so much for that. That really helps elaborate and understand the

thinking that (audio interference) application or eventually the full Kairos reactant design (audio interference).

So for our last formal presentation, I'd like to turn to Brad Tomer who will discuss the ongoing work at the National Reactor Innovation Center. Brad?

MR. TOMER: Thanks, Rob. And hello, everyone. Thank you for having me today. It's an honor to be here. Ashley Finan is our Director. She was supposed to speak today. She sends her regrets. She had a conflict come up and she couldn't be here today, so you have me.

Can you go to the next slide? So I believe rapid deployment of advanced nuclear technology is more important today than ever. You heard -- you probably saw two days ago on Tuesday, the International Energy Agency issued a press release. The global CO_2 emissions rebounded to the highest level in history in 2021 coming out of the COVID-19 crisis. So we can't afford to wait. And I believe DOE and NRIC are well positioned to rapidly deploy -- to help facilitate rapid deployment of technologies.

As Alison stated, you know, the U.S. Department of Energy -- the Nuclear Energy Program established NRIC in FY 2020 following the passage of the Nuclear Energy Innovation Capabilities Act. Our mission is really to partner with industry to bridge the gap between research and commercial deployment. It's not strictly a typical National Lab Program where we're doing all the research and we are partnering with industry to bring these things about.

We are located at the Idaho National Lab; however, to achieve our mission as Alison said, we are tapping into the resources and infrastructure of the entire National Lab Complex in the U.S. So we're bringing that resource to bear for all the reactor developers. And we are bringing an entirely new approach to managing the demonstrations -- trying to manage demonstrations to success.

We have a lean startup mentality. You know, I used to run a start-up. If you work with us, you'll hear things like, "Let's do the hardest thing first and fail fast if we're going to fail." Right? You'll hear minimum viable products. In this case, I'll show you some minimum viable test beds. Let's get something done quickly and we can work on

building -- building out later.

We're also bringing in a systems thinking approach. It's not just the reactor that needs demonstrated to go commercial. You really need to develop the ecosystem to support that reactor. We're bringing in advanced engineering techniques such as digital engineering and systems engineering. And our team -- we're building a team that has the background and knowledge to balance the needs of the public and private sector through partnerships.

Next slide. So our vision is simple. We plan to demonstrate two advanced reactors by 2025 to enable commercial deployment by 2030 and we are on schedule to achieve this vision. And while that vision seems simple, the path to achieving that is complex. And is going to require a lot of effort on a lot of people's parts.

Next slide. So to accelerate demonstration employment of advanced reactors, we are trying to take the comprehensive approach that includes inspiring stakeholders in the public. We have a lot of efforts that are associated with that. We're also trying to empower innovators by providing the tools and resources such as test beds and

experimental infrastructure. And I'm going to talk about some of those things as we go through this. And we're trying to deliver results through a fishing coordination of partners and resources. So we're talking about how we're bringing together the industrial partners, along with the lab complex, and provided facilities, et cetera.

Next slide. So partnering is the key here to everything we're doing. NRIC has taken a comprehensive approach to partnering that brings together all the stakeholders necessary to demonstrate and deploy advanced technologies. This includes things like people like the private sector, other labs, government agencies, regulators, and other essential tools and resources for the facilities and capabilities.

I mentioned a lot of those things, we do have a partnership -- a memorandum of understanding with the NRC. We have two folks that are assigned to us for the next year working through and making sure that we have those -- an eye on the regulatory efforts as we move these partnerships forward. This partnership allows us to leverage the expertise and resources of a diverse stakeholder base and brings

everyone together for a common cause. So we're bringing all these people together for one common cause.

Next slide please. So our priority is empowering innovators and we are going this through a variety of tools and resources. As you can see there, we are -- we are looking at -- I've got to get the slide up. I can't see it up there. We are leveraging existing infrastructure at INL and building two demonstration test beds. Alison mentioned both of those, but I do have a slide on one of them.

We're providing this to give reactor developers an opportunity to take their reactors critical for the first time in a safe environment. And if you think about it, if each individual reactor developer had to create their own confinement to take their reactor critical for the first time, it would inhibit, you know, the -- it would be cost prohibitive for some of those groups to do that.

To lead up to those demonstrations, there are key pieces of the technology puzzle that must be resolved. So to facilitate this, NRIC is investing in key experimental facilities that fill gaps in

existing infrastructure. I have a slide later on this that goes through each one of those. We are also investing in a virtual test bed where innovators can gain access to models so that they can do virtual tests prior to testing in physical demonstrations. And then we have a variety of regulatory and economic risk reduction programs.

We are looking at things like from transportation to disposition of fuels, demonstration reactor safety design analysis. The one real interesting project that we just awarded is cost-shared project with GE Hitachi that's going to actually demonstrate -- further develop and demonstrate some advanced construction techniques and technologies that has the potential to decrease nuclear build cost by 10 percent. And really reduce the risk of those builds as well. We're real excited about that. We just kicked that off in January. But that is part of that ecosystem that says okay, we need to demonstrate reactors, but we also need to make sure that they can be commercialized. And the infrastructure is very important to that.

We're developing and deploying multiple planning tools that can help innovators move faster.

Things like providing access to and funding for resources from and around the National Lab Complex to consult on projects. So we provide funding to the national labs to support reactor developers as needed in a consulting role. So we're really bringing that entire lab complex expertise to the forefront. And we're developing tools for helping companies determine if a site is suitable and if that's a STAND tool, then you can -- you can get access mostly to tools on our website.

Can we go to the next slide? I'm running out of time. So the next one is the NRIC-DOME slide, which you know, this is one of our test beds that Alison mentioned. DOME stands for Demonstration of Microreactor Experiments. You know, we're really trying to enable -- what we're going here is refurbishing the old EBR-II facility that operated from 1964 to 1994. It was a 62 megawatt equivalent reactor produced -- it operated for about 30 years. And then it was, you know, moth-balled. So we're reinvigorating that -- reestablishing that.

And you know, we had a plan -- the initial plan was hey, let's make this the most flexible test bed. You know, it's going to cost a lot of money and

it was going -- it was going to do a lot of things. What we decided to do was hey, we know we have about five reactor vendors that are very interested in this. Let's just make it so that they can test first. And then several years down the road, if we need to make it more flexible, we can add to it.

So we went with the minimum viable test bed. It's just flexible enough to test these first four and five reactors -- these small modular reactors using, you know, less than 20 percent enriched fuel. And you know, we're going to provide them confinement so they can take their reactors critical for the first time. We are oversubscribed for this test bed. We're going to have to, you know, schedule people in. We have our first customer coming in, in 2024. We've already had requests this past week for 2026. And we have other ones that want to get in, in 2025 and 2027.

So we're working through all that. This is going to be a very good opportunity for folks to test their reactors. As Alison mentioned, we do have another Safeguards Category I. I don't have a slide on it, but it was just actually officially approved as a project yesterday. So we'll be developing that

Safeguards Category I facility as well.

Next slide. This slide is our -- it shows NRIC experimental test facilities that we're actually working on leveraging existing infrastructure at INL and building a Helium Compound Test Facility. This is part of that thing. To lead up to demonstrations, we really need to test some of these high temperature gas reactor components in a non-irradiating environment at the -- at high temperatures and high pressures that they will see in the irradiating environment. But you need to try them out before you get there. Things like the helium circulator, the heat exchangers, the control grounds, et cetera.

We're also developing the Molten Salt Thermophysical Examination Capability. This will be the only test facility that will allow researchers to test thermophysical properties of irradiated fuel salts. This is supposed to come online in 2024. This will help inform modeling and simulation efforts and allow for more informed reactor design. We also fund the Mechanisms Engineering Test Loop Facility located at the Argonne National Lab. It is an intermediate scale liquid-metal experimental

facility. It provides purified R-grade sodium to various experimental test vessels so you can test components that are required to operate in the prototypical advanced reactor environment.

We are also designing, building, and testing an In-Hot Cell Thermal Creep Frame for the use with materials testing of advanced reactor materials. And in addition, I mentioned the virtual test bed where innovators can gain access to models they can use to do virtual tests prior to investing in physical demonstrations. Here again, we're making available models from anywhere that people can access, including NRCs models.

Next slide. So our goals, you know, we're going to continue to prepare our vital infrastructure. We're going to demo cost-cutting technologies. For example, I mentioned the advanced construction technology initiative we just awarded. We're going to be working through that this year. And you know, preparing for a demonstration in the future of these technologies. We anticipate -- We're trying to anticipate regulatory needs and things such as streamlining the NEPA process. You know, when we see "streamlining", we're trying to get it started

earlier, so we can finish it earlier.

We have also been just authorized by DOE to establish a safeguards guide -- I mentioned that already. We want to continue to build our team. We're not building a deep R&D bench, but we're bringing on folks that understand the urgency of the private sector and how to balance that urgency with the public sector interests. So we're really building out that team. Most of our folks have a combination or we have some with just industry experience that we're bringing in.

Next slide. So we've done this before. The nation built 52 reactors over 25 years of the National Reactor Testing Station, which was the predecessor to the Idaho National Lab in NRIC. We're going to do it again. Only this time, the private sector is going to be leading the way. NRIC is going to bring in new ways of doing business that is faster and more efficient such as I mentioned, systems thinking, digital framework, advanced engineering techniques, et cetera. So hopefully -- and all around these partnership approach to make things happen. Bring in all the best minds and all the best resources together to achieve one common goal.

That's my last slide of the day, Rob.

MR. TAYLOR: Thanks so much, Brad. I really appreciate that. You indicated that the NRC and NRIC are working together. We're going to be sending some staff up there. We see a lot of value to the activities that NRIC is undertaking. And the more we understood the information being selected and how it's going to be used, the more we can leverage it from our licensing approaches. So I think it's a great working relationship that we have (audio interference).

So maybe a question that I'd ask you to expand upon a little bit. As you develop these plans for all these activities that NRIC is going to take on, how are you keeping the capability for scaling work in mind so that you can support as many vendors and technologies as possible?

MR. TOMER: Yeah, so I like to use a landscaping analogy; sleeps, creeps, and leaps. When you first have a landscaper come out and install plants in your back yard or front yard, the first year the roots grow, but above the surface, it looks like the plants are not growing, so they're sleeping. The second year the roots are still growing and yet,

there is a little bit of growth. So it looks like they're creeping. And then finally, the third year, most of the growth is above ground -- above the surface and you see, you know, what we call leaps. So it's sleeps, creeps, and leaps.

NRIC is really following that kind of model. You know, NRIC is in the third year of existence. In the first couple years, we were doing a lot of designing and building the necessary foundation for these test beds and experimental infrastructures. And you know, building our talent to execute on projects, developing the planning tools that I mentioned, and expanding partnerships and resources across the lab. And most of these things are going to be coming online or starting this year or over the next couple years. Our big projects or our big test beds will be over the next couple years. So I think you're going to see a big leap in results -- a big scale up of results as we go forward.

I think we're in a good position in terms of being slightly ahead of industrial teams that need our facilities and resources. So we're going to be leading those test beds just prior to the reactor vendors coming in and doing tests. Of course,

obviously this will be dependent on the continued availability of funding and resources for NRIC.

So you know, I don't know if you heard yesterday, the House passed -- last night the House passed the Omnibus bill last night. And if it's signed by the President -- if it's, you know, passed by the Senate and signed by the President, you know, we'll see a good bump up in our 2022 budget over 2021. Now this is great progress and you know, we'll need even more in 2023 to finish the large scale test beds. But we're on a good trajectory and I think, you know, the foundation we're building today will yield results coming in the future.

MR. TAYLOR: Thanks, Brad. I really do appreciate that. And I appreciate the presentations from all of our panelists today. They were phenomenal. I'm sure they're going to generate a bunch of questions and we do see some already coming into us. So please, continue to do that.

So we're going to move now to the Q and A portion of the session. So please continue to feel free to submit your questions based on the dialogue that continues or what you've heard in the presentations. You can propose questions to an

individual or to the group at large. We'll do our best to answer as many of them as we can. We may not get to all the questions today, but we certainly appreciate those who are submitting them.

So maybe the first question is one that goes to a few of us. What is the current review schedule and review status of the application pursuant to pre-application engagements and projects? Maybe I'll start off and then ask Margaret and Rusty to provide their perspectives as well on this.

So the NRC last year did a substantial update to our advanced reactor web page and included within that web page is the ability to see and track the progress of different applications that are coming into us. So you can go to the Kairos portion of that web page and see all the pre-application work that came in under Kairos that we have reviewed and what its current status is. In addition, we put a dashboard in place. We're piloting a new dashboard on the Kairos review that gives the public a snapshot and perspective on the status of the review. And it's fed by real time data out of systems here at the NRC as we track and manage the work.

We've seen a substantial amount of

pre-application engagement from Kairos, as well as a number of other vendors. And we're completing reviews of topical reports and white papers for those vendors for those vendors so that they can have predictability and reliability in the licensing process as they go forward. So you can find that also on our web page and track all of the ongoing reviews, both under review and those in pre-application phase.

Margaret, do you want to provide any perspective?

MS. ELLENSON: Sure, yeah. Thanks for providing that context for us, Rob. Yeah, Kairos is currently working through preliminary questions from the NRC staff. We're working in parallel to finalize the associated topical reports that will support the review of the PSAR. And also NRCs development of safety evaluation. We're very happy to be continuing the pre-application engagement activities that we've had going throughout this application process and that's been extremely helpful. And otherwise, the review is proceeding on schedule as Rob mentioned and with that dashboard view that you can see on the website.

MR. TAYLOR: Rusty, did you -- do you want to add anything to that given you're starting pre-application opportunities with the NRC and what your vision is relative to that?

DR. TOWELL: Sure, I'd be glad to. You're right. We started our pre-application engagement and there was a whole session on that. Hopefully people were able to see that earlier this week. Where NRC is encouraging pre-application. They certainly have encouraged us and we've benefitted from that tremendously at this point. We have also benefitted from looking at what others have done. And so we appreciate Margaret and the whole Kairos team.

We have not submitted our construction permit. We expect to do that later this year. But we have opened up an electronic reading room to start that pre-engagement docketing discussion. And so the sort of early audit of individual components of a construction permit. We're finding that process very helpful. And overall, we're very much thankful for the advice and feedback we're getting on a regular basis in that pre-engagement process. And so we're optimistic that licensing will not be the hurdle that

everyone continues to look towards.

MR. TAYLOR: Thank you so much for that, Rusty and Margaret. And as discussed by the Commissioners, we don't want (audio interference). We want to enable the safety of these technologies. So we look forward to new engagements with companies such as both of yours.

The next question I have I think goes best to Alison. What capability does the virtual test reactor offer that things like the advanced test reactor and TREAT cannot?

MS. HAHN: Of course. So this is a really good question. VTR is a true test reactor, not a commercial plant. So VTR and NATRIUM both use sodium-cooled fast reactor technology, but they have very different missions with very different reactor cores and operating cycles. If you switch in comparison to ATR, for fuels at least, ATR can really only stimulate a thermal spectrum environment. VTR is essential if you're going to be developing fuels for fast spectrum reactors.

And then on the material side of the house, ATR can only impart DPA damage on the order of ten DPA per year. Whereas VTR can impart up to, you

know, 30+. So for materials that are going to stay in a reactor for longer periods, especially fuel climbing, VTR is essential. At a minimum, it's the difference between one year of irradiation in VTR versus three in ATR or two versus six and so forth.

MR. TAYLOR: Thank you for that, Alison. I think the next question will go well to Brad. So what impact do you expect NRIC to have on the nuclear industry at large? And how do you see NRICs mission changing as we progress and see advanced technologies begin to operate?

MR. TOMER: So we are -- you know, our mission will change. But for right now, we are building the infrastructure necessary to do the demonstrations that we envision. Right? And so once we -- once we transition to doing the demonstrations, we want to manage those demonstrations to success.

You know, we're focused a lot right now on demonstrating high temperature gas reactors. There are other types of reactors. You know, we have -- one customer is going to be using our facility as Safeguard Category I facility as molten chloride reactor. You know, there's a lot of technology. So technologies that are in different stages in

majority, I would say. And so as we progress through one technology, we can move on to the next technology.

But ultimately, you know, a few years down -- ten years down the road or something, you know, you want to -- you want to work your way up as it's written. So you want to get to the point where things are commercial and you don't need this program anymore. So we consider ourselves similar to a start-up. So we started up something here and we're working through that start-up phase. And you know, we'll grow it into a bigger business and then we'll sell it.

MR. TAYLOR: It really sounds like NRIC can be (audio interference) to so many different things (audio interference) -- look forward to following the good work that they're doing.

So a question here that probably goes a little bit to me and to some others is what are major attributes of a submittal? What would positively influence and encourage an effective NRC review? And maybe I'll start and then lean into Margaret and Rusty (audio interference).

(Audio interference) applications to us. So first and foremost, you can't underestimate or

undersell the importance of effective pre-application. Recognize that these vendors are working on their technologies for years before they ever come in and engage with the NRC. And while the NRC has robust training programs for our staff to be prepared for different varieties of technology, we won't be familiar with the unique safety and operational profiles for the facilities or the vendors who are developing unless we get early engagement with them. And that can so effectively influence whether we hit the ground running and how effectively we hit the ground running on the review.

I would say that Kairos is a perfect example of that. The pre-application that Kairos did has allowed the NRC to set a very aggressive review schedule of 21 months and establish a resource estimate that would effectively manage and currently under burning relative to the budget that we proposed. So we're affecting the review in a very focused and systematic way because of the good work that Kairos did on that.

Another thing I'd really emphasize is in the applications, make sure you tie that nexus between the risk aspects of the design and the safety

profile for the facility. Make sure we understand what you perceive to be the most important design attributes and the most risk-significant elements of the design. Because the better we understand that (audio interference) review, the better we'll be positioned to focus our review on those aspects and spend less resources and effort in the actual review.

And finally, as the Chairman said in his opening remarks, make sure you show your work in the application. There's a lot of -- we hear you. We want these designs to be safe. Provide the basis for why in the work that you did. Show those attributes and the safety profiles are demonstrated. Because otherwise if you make an assertion without the supporting rationale behind it, we're going to have to ask the questions to understood why. So those are the kind of things I would say.

Margaret, Rusty, do you guys want to weigh in on this?

MS. ELLENSON: Yeah, I can -- I can kick it out if you like, Rusty. I absolutely agree with your points about pre-application engagement and being clear about defining the truly risk-significant aspects of the application. That we have found that

to be a very powerful and important aspect to pre-application and to positively influence as the question said, the effective NRC review.

I'd also say that delivering an application that focuses on the finding that the NRC needs to make. We put a lot of thought and effort into what is it that we actually need a finding about? And really tailoring the content of the application and focusing the application on what do we need to support that finding?

It's important because it not just makes sure that we put the right information into the application, but also that we don't distract the review with other unnecessary details. And we've also found that topical reports have been a great tool to be able to align on the necessary level of detail, as well as the pre-app engagement on the application itself. So both of those things have been very useful tools to us to make sure that we can deliver an application that supports the finding that NRC needs to make.

DR. TOWELL: I'll just say it's a great question. It's very -- it's a question we're asking almost daily here as we're in the midst of writing

our CP. But certainly pre-engagement is helpful to get some of those answers. And I think, you know, there's a lot of guidance out there that's being developed for advanced reactors. Obviously as that continues to grow and gets tailored for the different technologies, that will be helpful. But right now, this is just a great question and we're trying to answer it the best we can every day.

MR. TAYLOR: Okay, thank you. So maybe the next question, I think is a good one because it opens up to everybody. I welcome who wants to weigh in on this question. What do you see as some of the most significant long-term technical barriers to developing advanced reactors? Is there anybody who wants to maybe start us off on that?

MS. ELLENSON: I can chime if you'd like, Rob. Just from KPs perspective, we don't see particular technical challenges that are not resolvable. We use our rapid iterative development approach that allows us to learn from building new hardware. It also allows us to resolve substantial technical challenges very quickly.

We do need to -- part of our objective is to achieve cost certainty. So to do that, we need

to prove both technology certainty, supply chain and manufacturing certainly, licensing certainty, construction certainty, all these things. So that's why we're heavily investing in testing and manufacturing infrastructure as the best way to resolve those technical roadblocks.

Some other things that come to mind that perhaps are well known, the reliable sources of HALEU -- high-enriched low-assay fuel. But we don't necessarily see that as a barrier to technological development, just something that we need to work through with industry, DOE, NGOs. And then also a couple other points perhaps is -- an important challenge is workforce. Making sure that we have the right expertise, both in development of our industry and in the NRC or other government bodies to be able to support deployment.

And then lastly, it's not really a hard technological barrier, but the viewpoint that can hamper technological development is the idea that all systems at a reactor site need to have a higher pedigree than other hazardous industries. So really making sure that we're consistent with state of knowledge, not just for the nuclear industry, but for

all hazardous industries. So those are a few thoughts.

MR. TAYLOR: Thanks, Margaret. Anybody else want to weigh in? Alison.

MS. HAHN: I don't want to -- I don't want to speak for industry of course, but some of the challenges that we've heard on our side is cost and schedule for construction. And I know that Brad had mentioned it briefly, but NRIC has our advanced construction technology -- ACT initiative that could significantly reduce the cost and schedule for advanced reactor construction. I mentioned the virtual test reactor in the presentation, but having conditions to test materials and fuel, which is what VTR would do. And the test bed. Having those test beds to bring in and have infrastructure to test these designs in a safe environment could certainly help the deployment.

MR. TAYLOR: Thank you. Rusty, do you want to weigh in on that one?

DR. TOWELL: I'll just reiterate. I think Margaret gave a great answer. I think that the technical hurdles are not the biggest hurdles in this project. In fact, the technology's been deployed

before. It can be deployed again. Certainly there's room for optimization. And so I see that as a lot of the areas we're working on is how can we make it more efficient, more cost-effective?

And so then you come right back to the issues of how can you de-risk the whole process of developing or more importantly, deploying? And I think that's where more of the risk is, is not in can we build a reactor or can we license one, but can you somehow de-risk the process and provide certainty on commodities on pricing and schedules so that it's de-risked as you think about deploying this technology.

MR. TAYLOR: Thank you for that, Rusty. Maybe while I have you, the next question I think is really good for you and something we should always keep in mind. So how do you -- how do the universities support the pipeline for future engineers and scientists? Are students interested in nuclear development? Are you seeing a growth and interest in nuclear engineering types of pathways?

DR. TOWELL: So the short answer is yes. We have tremendous student interest in this project. Every incoming student that has anything to do with

STEM wants to hear about this project. And last summer, we had 65 students working on the project here at Abilene Christian University. Those students primarily came from ACU, but they also came from our partner schools. This year without advertising, we've had students apply from seven different universities to come and work with us this summer.

We have also been told by our research alliance schools that their graduate program enrollment or applications is way up because there are students that are hearing about the project that want to figure out how they can be part of it. And so there's certainly students there. I mean clearly if you can -- if you can take your skill set and apply it to real world problems and develop the technology that's going to help address some of the world's most critical needs, that's something that students love to be involved with.

And we really view -- you know, a central part of our mission is that workforce development and how can -- what can we do to help educate that next generation of scientists and engineers that are going to be critical to not only operate these advanced reactors, but help continue to develop their designs

and deployment. And so that's something we enjoy doing. It obviously brings a lot of energy in the project when you have a bunch of students working on it.

And one of the joys is this is a real world, very interdisciplinary project. And so our students come from all different backgrounds, not just nuclear engineers, but also flavors of engineering and chemistry and physics and even math and computer science. And so we have a lot of student interest in the project. And so I don't think we have to worry about it. The student interest is there. We're going to be able to fill that work pipeline as long as the universities are ready for the flood.

MR. TAYLOR: That's great, Rusty. I think in some previous presentations this week, we talked about the Commissioners and Dan and others talked about the significant hiring that the NRC has to do. We recognize that the industry is doing significant hiring as well, as well as DOE as they stand up the clean power project organization. So that pipeline is so critical and it's so exciting to see that enthusiasm and invigoration in young

individuals entering STEM and doing research in technology that will support as all as we progress forward.

The next question, I think goes best to Alison and Brad. What is the benefit of DOE and NRIC supporting multiple designs and vendors compared to focusing resources on one?

MS. HAHN: Yeah, so I can start off. I was looking at Brad to see if he was jumping in. But we have set very ambitious climate change goals, net zero by 2050. We're going to need a diverse set of reactor designs to meet those goals and to support energy resilience and security. But it really falls back on it is not DOE's role to pick the winners. We are here to reduce the technical risk for the broadest set of reactor designs. And each design offers unique features which could meet different missions. And so we really want to try to address as many -- as many reactor types as possible.

MR. TOMER: Yeah, I agree with everything Alison said. I would just add that it's up to the individual companies to focus on what they think is best. We're going to allow people to come in and test their systems that they're focusing on so we

don't have to pick the winners as Alison said. And coming from the private sector into this, you know, I was in charge of developing technologies and we wouldn't want DOE picking the winner. We would want to focus on what we think we can do best and have the best opportunity to commercialize that.

And you never know what's going to derail a project. So you can -- so DOE could focus on one technology and you could get down to the end and maybe financing or maybe something else that will destroy the project. Whereas if you have a portfolio or a pipeline of technologies that you can get, that's in the best public good. You know, because you're going -- you're going to eventually get a winner out of that pipeline. And that's going to be where -- and actually deploying that technology is going to be where the public good comes in.

So I think in this partnership, allow the demonstrators to focus on what they think is best and give multiple -- the DOE give multiple opportunities to multiple people -- to companies to try to bring technology to the forefront. Sort of make it a competitive thing. And there's also different applications for a lot of different technologies as

well. So you know, that's another thing. You know, it depends on the market you're targeting.

MR. TAYLOR: Great. Thank you, both for that. I think a good question here for Margaret is while Hermes is going to help with the engineering of the full power reactor, how will the siting process for Hermes help Kairos on the efficient siting of a full scale power reactor?

MS. ELLENSON: Yeah, that's a good question. As far as the requirements go for a difference between a non-power reactor and a power reactor, there's a lot of overlap. There's a lot of similarities. The NEPA regulations can be exercised through the non-power reactor as well. Part of what makes it very similar for this test reactor is kind of a full exercising of that process.

There are a couple of differences about the type of data that can be sited for a non-power reactor versus a power reactor, that type of thing. But in general, I think a lot of the processes are similar. A lot of the steps that we will need to go through to do a siting analysis and to do the environmental report development are similar.

So there's a lot of lessons that we can

learn through the non-power reactor application as well. We're obviously working through some of the questions with the NRC now on the environmental report review that supports the Hermes application. And we're excited to see that great progress is being made there on a really fantastic schedule. So good work happening on that front I would say.

MR. TAYLOR: Great. Thank you for that, Margaret. The next question, I think I want to propose to folks -- and I'll certainly seek to answer it. Maybe I'll hold mine to the last. How are you working international partners to develop and regulate advanced reactor technologies?

Alison, I know DOE does a lot of work in this area. Could you elaborate on your perspectives on how we do that?

MS. HAHN: Of course. So we have a number of bilateral and multilateral collaborations with countries on this advanced reactor technology. We are also -- Sorry -- Gen IV International Forum -- I had to spell it out in my mind. We are also a part of that with some other like-minded countries looking at a variety of advanced reactor technologies. And so it's really -- we recognize the

importance of these collaborations to leverage the limited resources we have sometimes. And to have a seat at the table to provide input on safety -- on safety decisions as it goes forward across -- across the globe.

MR. TAYLOR: Does anybody else want to weight in before I do?

DR. TOWELL: I won't speak to the regulatory part of the international collaboration. But I will say that the need to develop a pipeline of next generation leaders is something that countries have already identified as a need if they want to consider nuclear. And so we've been approached by some countries and their universities in those countries, what would it look like to partnership at a university level to help develop that pipeline and you'd have access to an advanced reactor if they're considering being a nuclear country? And so international cooperation is huge. I think it's on the regulatory side. It's the pipeline development side. I think it's something that's great to work with our international partners.

MR. TAYLOR: Great. Thanks, Rusty. Maybe I'll just weigh in here. The NRC is

placing -- if you've been watching some of the other presentations, including the ones before this with Dan Dorman and some of our international counterparts, the NRC is placing a huge emphasis on international engagements, either through things like the NRC and CNSC Memorandum of Cooperation, which includes something we're discussing now that may involve NRIC in the future as an opportunity to engage. We see those as critical as they are the first steps to looking at how do we license potentially and leverage similar approaches to making regulatory decisions in countries. And candidates with the NRC have a lot of similarities with our regulatory approaches.

But we're not stopping there. We know that there's lots of good work that the International Atomic Energy Agency is doing. They participate in things like the Small Modulator Reactor Regulators' Forum there and share our perspectives and gain perspectives from a number of other member states to the IAEA. And then a good example is what we've done with NEA fuel qualification. There was a working group there that developed an approach for fuel qualification that could be an international

approach. We've taken that and adopted it slightly and incorporated it into our regulatory guidance as well.

So we're trying to leverage those good practices that are done internationally and share our good practices so that we can streamline the ability of countries to leverage the work done in other countries. So we see that as a critical activity going forward. Because advanced reactors are not just a national project, they're an international and a global project that most of these countries are emphasizing the importance of deployment in other countries as well.

So the more we do to standardize our approaches, the more we can streamline that progressive deployment and ultimately end the value that we were hoping to see, which is its effects on climate change and things like that. So I think it's a great opportunity.

Sorry about that. I muted myself unintentional. What additional pools or resources would facilitate developing new technologies and getting them to market?

MS. ELLENSON: I can weigh in, Rob, if

you like. There's some technology development areas that are suitable for standardization and maybe cross implementation. There's been a few technology working groups or TWGs that have been established. And we've found those to be beneficial. For example, we currently participate in the Molten Salt High Temperature Reactor Working Group. It has helped with the development of the TRISO fuel topical report that we have developed. And establishes a technical baseline for the TRISO testing work that will be done at LANL.

There's other opportunities for common development. And I think while not an exhausted list, some other examples of cross technology development might be generic perks for common phenomenon and perhaps making modeling capabilities and expertise that can be used by both industry and NRC. Those are two thoughts that come to mind.

MR. TAYLOR: Anybody else have any perspectives?

DR. TOWELL: So one thing I'll just add that's of concern to ACU is the Research Reactor Infrastructure Program from the Department of Energy. As a university research reactor, we're looking to

partner with the Department of Energy to get our fuel. This is obviously a new fuel form for them in the advanced reactor world. And so that partnership is something that we are relying on. And they can't do their job without, I guess, funding. And so we're watching funding bills and making sure that, that Department gets the resources they need.

And then looking down the road in terms of commercial deployment, I think something that we have to address as a nation is if we're rapidly deploying small modular reactors or microreactors, the licensing process has to be streamlined. And what does that even look like? That's something that we probably all should look at together and think about what that process might look like.

MR. TAYLOR: I couldn't agree more, Rusty, on that one. And I think one of the things, it's a theme, I think, to all of the presentations we've heard today is the work that's being done in research and development and those activities are critical to this. Because they're going to provide and identify the best practices that can be employed across technologies -- that are technology neutral in a lot of different respects. Some of it will be

technology specific if it's related to the fuel and the design and the reactor. But a lot of things at construction.

There's a lot of lessons learned and good experiences from the activities at Vogtle on construction that we did not lose or overlook as we prepare for constructing new and advanced reactors going forward. So we've got to be able to share that information in doing the best practices. And then have everybody understand them so they can take them into account and incorporate them in their activities and their preparations.

So for the next question, it goes to me and it relates to the Oklo review. And it asks if Oklo resubmits and closes the information gaps identified, do you expect the application review to be able to resume where it left off? That is our desire. We want to leverage as much as we accomplished in the Oklo review and the working relationships we established with Oklo during that review.

We didn't start some portions of the review because we were focused on getting the key safety profile understood in that design. So once we nail down that safety profile and resolve those

issues with Oklo, it should help streamline and focus our efforts and activities on that review. And I think Oklo is committed to that as well.

So we're starting the discussion about the schedule for resubmittal and how we're going to engage between now and when they do to try to draw out those issues to closure and get the information we need as the regulator to make our safety findings. So we're excited to resume those activities with Oklo when they're ready to engage and work with us.

Here's a question that's a little bit different. And we've been focused a lot of fission technologies in the discussion. And most of you are focused on that as well. But we recognize fusion technology is out there. NEIMA acknowledges that our frameworks have to work -- the NRCs frameworks have to work for licensing of fusion technologies as we go forward. And we're very conscious of that as we prepare our approaches and think about how fusion technology may be regulated in the future.

But how do you -- how do folks feel or think about fusion technology fitting into the future of non-power and advanced reactors? And maybe Alison, it might be a good place for you to start

because it ideally (audio interference) if you're comfortable.

MS. HAHN: Yeah, so DOE does do work in fusion reactors. It's more through the Office of Science. And I believe ARPA-E does work with fusion as well. But like I said before, to meet our energy goals, we're going to need a variety of reactors. And if fusion technology is able to be deployed within that timeframe, then absolutely. There's a spot on the board for them as well.

MR. TAYLOR: Anyone else? I know Kairos isn't pursuing it. So I didn't know if anybody else had a perspective on fusion based on their experiences. But I do appreciate the individual asking. And the NRC is definitely engaged on activities related to fusion and preparing for that. We know the Fusion Industry Association out there is working with a number of potential developers and technologies related to that. And the question becomes what is the regulatory footprint that really needs to exist for fusion technologies? They potentially have substantial safety benefits and risk profiles that may warrant treating them different than we've treated historically production and

utilization in a facility. So we're looking at that and thinking about what the right approach for that will be going forward. And we encourage engagement on that.

One of the things maybe I want to touch for folks is this panel is just one of many things we do as the NRC for public and stakeholder engagement as we emphasize openness and transparency in our (audio interference) regulation. We have routine public meetings about every six weeks on the Advanced Reactor Program and where we're going as an agency. And we bring in many entities to help us and discuss and dialogue various aspects during those meetings. And we discuss the status and updates, key guidance, and rulemaking activities and things like that, that we're doing.

And this year, we're doing a number of -- we're doing extensive stakeholder outreach on Part 53, which we think will be instrumental and critical in the future for licensing these advanced technologies because it's going to provide a more performance-based technology, which includes a risk-informed approach to how to license and look at designs like Kairos, designs like what Abilene

Christian is doing. And how can that be more efficient? And then taking into account the differences between the requirements in the Atomic Energy Act under Section 103, which is the power reactors and Section 104, which is for non-power reactors. So we have to factor all of those things into what we're doing.

So we're just about out of time. And we're not seeing any more questions come in. So I'm going to go ahead and suggest that we wrap up this session. I want to express my profound appreciation to the panelists. Today I found your presentations insightful and thought provoking. So I think we have a lot of work and I think we're all partners in getting to the end while respecting our individual roles. But if we're going to get to the deployment of advanced reactor technologies, we have to all communicate and continue to work together effectively.

So thank you all for your time today and I appreciate it. And I thank the audience for the questions that they proposed. So with that, let's go ahead and close up this session. And everybody have a wonderful day.

(Whereupon, the above-entitled matter went off the record at 11:59 a.m.)