

UNITED STATES  
NUCLEAR REGULATORY COMMISSION

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BRIEFING ON REGULATORY APPROACHES FOR FUSION  
ENERGY DEVICES (PUBLIC MEETING)

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TUESDAY,  
NOVEMBER 8, 2022

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

COMMISSION MEMBERS:

CHRISTOPHER T. HANSON, Chair

JEFF BARAN, Commissioner

DAVID A. WRIGHT, Commissioner

ANNIE CAPUTO, Commissioner

BRADLEY R. CROWELL, Commissioner

ALSO PRESENT:

BROOKE P. CLARK, Secretary of the Commission

MARIAN ZOBLER, General Counsel

PANELISTS:

SACHIN DESAI, General Counsel, Helion Energy

DR. RICHARD HAWRYLUK, Senior Technical Advisor, Office of Science,  
U.S. Department of Energy (DOE)

DR. SETH HOEDL, President, Post Road Foundation

EDWARD LEWIS-SMITH, Head of Domestic Fusion Policy and Programmes  
UK Government Department of Business, Energy and Industrial  
Strategy

DR. KATHRYN McCARTHY, Associate Laboratory Director for Fusion and  
Fission Energy and Science, Oak Ridge National Laboratory (ORNL)

DR. BOB MUMGAARD, Chief Executive Officer, Commonwealth Fusion  
Systems (CFS)

MEGAN SHOBER, Nuclear Safety Specialist, Wisconsin Division of Public  
Health

NRC STAFF:

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

ANDREW PROFFITT, Project Manager, Division of Advanced Reactors and  
Non-Power Production and Utilization Facilities, Office of Nuclear  
Reactor Regulation

DR. JOSEPH STAUDENMEIER, Senior Reactor Systems Engineer, Division  
of Systems Analysis, Office of Nuclear Regulatory Research

ANDREA VEIL, Director, Office of Nuclear Reactor Regulation

DUNCAN WHITE, Senior Health Physicist, Division of Materials Safety,  
Security, State, and Tribal Programs; Office of Nuclear Material Safety  
and Safeguards

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

(9:00 a.m.)

1  
2  
3 CHAIR HANSON: Good morning, everyone. I convene  
4 this public meeting on the regulatory approaches for fusion energy devices. I  
5 think it's important to keep the public informed of the Agency's development  
6 in this area of very high interest.

7 So, I thank you all for supporting this meeting today and I'm  
8 looking forward to a great conversation. We'll hear from two panels this  
9 morning and then we'll take a short break in between. With each panel we'll  
10 hold questions until the end and then we'll hear from Commissioners, where  
11 we'll hear from Commissioners and their questions for the panelists. Before  
12 we start, I'll ask my fellow Commissioners if they've got any remarks they'd  
13 like to make?

14 Okay, we will begin with the first panel, we're going to dive  
15 right in with Dr. Kathy McCarthy, who is Associate Lab Director for Fusion and  
16 Fission Energy and Science at Oak Ridge National Lab. Dr. McCarthy?

17 DR. McCARTHY: Thank you very much. Now that I have  
18 the button figured out, I think I can start. Thank you to the Commissioners to  
19 the opportunity to speak with you today. My name is Kathy McCarthy, I am  
20 currently the Director of the U.S. ITER project. I was the Associate  
21 Laboratory Director up until couple of months ago so I've done both roles, at  
22 the same time at one point, and I'm based at Oak Ridge National Laboratory.  
23 I'm a member of the National Academy of Engineering and a nuclear engineer  
24 by training.

1 I'm here today to describe the value of National Laboratory's  
2 support in the development of commercial fusion, and I'm going to use the  
3 capabilities at Oak Ridge National Laboratory as a specific example. But  
4 capabilities exist in multiple of our Department of Energy national laboratories,  
5 so think of these as representative, not the only ones.

6 Oak Ridge National Laboratory has over 60 years of fusion  
7 experience and contributes to diverse fusion efforts around the world,  
8 including the international ITER project, which I lead the U.S. portion, to  
9 demonstrate a self-heated plasma of 500 megawatts.

10 As an expert who has worked extensively in the fields of  
11 both fusion and fission at multiple national laboratories, three, I think it's useful  
12 to note how fusion differs from fission. Fusion would produce limited long-  
13 lived waste compared with fission reactors and that waste is primarily by  
14 activation of structural materials. And we do have the opportunity to develop  
15 what we call low-activation structural materials, thereby tailoring that waste to  
16 some extent. Fusion fuels are broadly available and could promote global  
17 energy equity. There is no risk of runaway reactions with fusion and the  
18 proliferation risks are considered lower than for fission.

19 When we compare the current fusion systems to advanced  
20 reactor fission systems, we also see substantial differences in their respective  
21 stages of development. The technology for most advanced fission reactors  
22 has been demonstrated at some scale, typically, often at commercial scale in  
23 some form. Multiple qualified or tested fuels exist and some advanced  
24 reactors have already been demonstrated commercially.

1           As a result, there is some range of operating experience  
2 with advanced fission reactor technology. In contrast, fusion is not yet at the  
3 demonstration stage. While at power-plant scale, even ITER is an  
4 experiment, designed to be a science experiment with a strong focus on the  
5 plasma physics related to a self-heated plasma. This is essential  
6 understanding for practical fusion energy. Fusion fuels may be deuterium  
7 and tritium, as in ITER, and as demonstrated in the Tokamak fusion test  
8 reactor and the joint European Taurus, or it could be other fuels, such as  
9 Deuterium Helium-3 or proton Boron-11.

10           There are pros and cons with each of these fuel cycles and  
11 a complete fuel cycle is not yet developed. A wide variety of fusion reactor  
12 designs is under discussion. Different configurations will have different  
13 implications for the associated fuel cycle and the operating demands.

14           The 2021 National Academy's report on bringing fusion to  
15 the U.S. grid outlines essential fusion technology performance needs for a  
16 pilot plant, from demonstration of safety and economic viability to reliability  
17 and availability. And of course, those things are all connected.

18           As a national laboratory, we contribute sustained R&D to  
19 resolve technical challenges and advance technical readiness of diverse  
20 fusion systems. We're working on the three major challenges facing practical  
21 fusion energy. We're preparing to produce and operate a self-heated plasma  
22 with ITER. As a highly diagnosed science experiment, ITER will deliver key  
23 data and experience in this area to bring us to commercial fusion.

24           Second, we're developing materials that can perform in

1 extreme fusion environments. At Oak Ridge National Laboratory, we're  
2 building the materials plasma exposure experiment, or MPEX, to provide a  
3 platform to test fusion materials relevant for a fusion pilot plant. MPEX  
4 represents a shift from the historical direction of the plasma material  
5 interaction field, which for many years focused on the effect that materials had  
6 on the plasma, but not on the effect that plasma had on the materials. And  
7 that's very important.

8                   Third, as home of DOE's national fusion and blanket fuel  
9 cycle program, we're preparing the development of technologies that will close  
10 the fusion fuel cycle efficiently and safely. We're also involved with long-  
11 range planning for efficient, safe, and reliable delivery of fusion energy from  
12 source to consumer. And because we have the resources of a multi-purpose,  
13 multi-user facility national laboratory, we're integrating advanced  
14 manufacturing, artificial intelligence, and modeling simulation for fusion  
15 technologies and systems. We know that integration across technologies is  
16 critical for fusion systems to be successful.

17                   National laboratories also provide important input for  
18 regulatory decisions, as evidenced by fission. Examples include R&D and  
19 technology development in the DOE light-water reactor sustainability program,  
20 materials in fuel development qualification supported by DOE and/or private  
21 industry, and expert input for licensing support. National laboratories work  
22 closely with private industry in many areas, making unique expertise and  
23 facilities available to solve the challenging problems that private industry  
24 faces.

1                   From my perspective in the ITER project, I know that know-  
2                   how and R&D from ITER is already benefitting the U.S. fusion program and  
3                   will continue to provide access to essential knowledge and expertise in  
4                   multiple areas. These are areas such as tools for plasma control and  
5                   performance, high-power plasma heating, deuterium fuel cycle technologies,  
6                   superconducting magnets, fusion power handling and plasma diagnostics.

7                   DOE is in the process of establishing a process to facilitate  
8                   industry access to ITER information of interest, including lessons learned from  
9                   designing, fabricating, and assembling fusion components. And you can't  
10                  underestimate the value of that actual construction and assembly, and the  
11                  lessons learned from that.

12                  Industry participation in DOE programs like Infuse, the  
13                  innovation network for fusion energy, shows us that private fusion values  
14                  national laboratories' support for enabling fusion technologies. So far, 65  
15                  projects from 19 private companies have been supported by Infuse. Oak  
16                  Ridge National Laboratory is contributing to 22 of those projects for the  
17                  following companies: Commonwealth Fusion Systems, Energy-driven  
18                  Technologies, General Fusion, Princeton Fusion Systems, TAE, Tokamak  
19                  Energy, and Type 1 Energy.

20                  In summary, Oak Ridge National Laboratory together with  
21                  the national laboratory system, brings decades of expertise in fusion science  
22                  and technology, including a variety of confinement approaches and offers  
23                  important resources for fusion industry and NRC needs. We're working  
24                  effectively with fusion industry to support enabling technologies and advance



1 the technical readiness of fusion systems. Thank you for your time and I  
2 welcome questions that I know will come later in further discussion.

3 CHAIR HANSON: Thank you, Dr. McCarthy. Next we'll  
4 hear from Dr. Richard Hawryluk, who is a Senior Technical Advisor in the  
5 Office of Science of the Department of Energy. Dr. Hawryluk?

6 DR. HAWRYLUK: Thank you for this opportunity to talk  
7 with you today. Just a little bit of my background, I've worked in fusion for a  
8 long time at the Princeton Plasma Physics Laboratory in various senior roles,  
9 including, as is of relevance today, as head of Tokamak fusion test reactor in  
10 the 1990s when we did the deuterium and tritium experiments. And I was  
11 also on the ITER project as Deputy Director General for Administration. So,  
12 it's really my pleasure today to talk to you about the prospects for  
13 commercialization of fusion energy. Next slide, please.

14 Let me talk about some of the recent developments in  
15 fusion. Fusion is potentially a global, scalable, firm, carbon-free energy  
16 source that can help the United States and the world reach sustainable net  
17 zero. Recently, the United States has been forging and changing the fusion  
18 landscape and the changes have been substantial and significant. This has  
19 been enabled by decades of public investment, which has set the foundations  
20 for the science technology but a lot of innovations are taking place currently.

21 There have been major scientific and technological  
22 advances, which I'm going to describe, and there's been a dramatic growth of  
23 private investments. You'll hear about that from the other panelists. There's  
24 been demand for accelerated strategy for fusion research development

1 deployment, both to maintain U.S. leadership and to contribute to net zero  
2 goals.

3                   In March of this year, the White House had a fusion summit  
4 which signaled the ambition to realize a fusion pilot plant on a decadal  
5 timescale by partnering with the private sector. This was informed by  
6 National Academy's report, Bringing Fusion to the U.S. Grid, which I had the  
7 privilege of chairing and actually, Kathy was on that panel with me, which was  
8 great, and the FESAC long-range plan, which came out around the same time.  
9 Both of these documents recognize the importance of public-private  
10 partnerships as a key opportunity to accelerate fusion. The Secretary of  
11 Energy at that meeting announced the new DOE fusion cost-cutting initiative  
12 to develop all of DOE fusion energy strategy. We are now moving ahead  
13 aggressively on that. There has been a funding opportunities announcement  
14 released to start the milestone-based fusion development public-private  
15 partnership program. Next slide, please.

16                   The United States is forging a changing fusion landscape  
17 and you can see this in some of the technical achievements shown in this  
18 craft. The National Ignition Facility at Livermore achieved 1.3 megajoules,  
19 which is a major achievement in the IFE area, and also started a study of  
20 burning plasmas in that configuration. Our colleague at the panel here, at  
21 Commonwealth Fusion, achieved a 20 tesla HTS magnet demonstration coil,  
22 which opens a new pathway to magnetic fusion. Kathy and her team working  
23 with General Atomics delivered a central solenoid module to ITER, which is a  
24 huge magnet of central importance to the project.

1           On the right side of this graph you'll see the increase in  
2 funding, increasing funding on the public side by a very dramatic increase in  
3 funding on the private side, showing the interest in the private sector. Next  
4 slide, please.

5           Fusion companies have raised greater than \$5 billion of  
6 private capital. Fusion industry associates have formed in 2018, 29 member  
7 companies and they span a wide range of different configurations and different  
8 fuel cycles. This is very important because this has regulatory issues related  
9 to how flexible the framework should be to address the breadth of the  
10 community, which is a lot of smarter than it used to be in the past. And these  
11 private companies are now building some of the largest fusion experiments in  
12 the United States. Next slide.

13           I'm going to just mention some of the key recommendations  
14 from the National Academy report, Bringing Fusion to the U.S. Grid. To  
15 ensure the United States leadership and to impact the transition to net zero  
16 by 2050, DOE and the private sector should demonstrate net electricity in the  
17 fusion pilot plant in the 2035 to 2040 timeframe. At the White House Summit,  
18 they declared ambition to even further accelerate this to the early 2030s.  
19 DOE should move forward now via public-private partnerships to develop and  
20 bring fusion to commercial viability.

21           As a first step in that pathway, we've announced that a  
22 funding opportunity for milestone-based fusion development program. There  
23 is obviously a need for urgent investment by DOE in the private sector to  
24 resolve the many important scientific and technical issues to realize a fusion

1 pilot plant. And we're working to make that happen.

2                   Let me go to the last slide, which is perhaps the most  
3 important for this meeting, how important it is to demonstrate safe operation  
4 of fusion pilot plant, which has to be one of its most important goals. For  
5 someone who manages a Tokamak fusion test reactor during the deuterium  
6 tritium experiments, this was always of paramount importance to me  
7 personally.

8                   DOE will support the NRC in developing a risk-appropriate  
9 fusion regulatory framework that provides regulatory certainty, ensures public  
10 safety, and enables investor and developer confidence by minimizing  
11 unnecessary regulatory burden. In this way, it will address equity, energy  
12 justice, and environmental concerns. This is extraordinarily important.  
13 Fusion is fundamentally different from fission. Kathy discussed that in her  
14 previous comments, no special nuclear materials and no concerns about  
15 criticality. Therefore, in the Academy report we discussed how 10 CFR Part  
16 50, which is tailored to fission power reactors, is not well suited to fusion  
17 technology.

18                   Tritium dominates the source term and mitigation of tritium  
19 is key. My experience from TFTR, JET, the National Ignition Facility, and the  
20 design of ITER can be leveraged. We've learned a great deal about how to  
21 handle tritium, how to handle it safely. I just want to re-emphasize at the end  
22 of my presentation here, that the DOE wants to work closely with the NRC and  
23 offer technical advice and experience to bring fusion to commercial reality and  
24 to make sure we address all the safety and regulatory issues. Thank you

1 very much for your time.

2 CHAIR HANSON: Thank you, I really appreciate that. Next  
3 we'll hear from Mr. Edward Lewis-Smith, he's the Head of Domestic Fusion  
4 Policy and Programs with the United Kingdom Government, Department of  
5 Business, Energy, and Industrial Strategy. Often we'll have remote  
6 participants but this may be the remotest yet. Mr. Lewis-Smith, welcome to  
7 the proceedings today and we look forward to your remarks.

8 MR. LEWIS-SMITH: Thank you very much for inviting me  
9 to join you, I hope you can hear me and that there isn't too much of an echo.  
10 I've got a few slides but I'll go through them quite quickly to provide an update  
11 from the U.K. on what the U.K. Government is doing in fusion regulation.  
12 Next slide, please.

13 So this just gives you a quick outline of the U.K.  
14 Government's fusion strategy, which is important context for our work on  
15 regulation. And you can all read that, I'll quickly go onto the next one and talk  
16 about regulation on the next slide, please.

17 What we've been doing in the U.K. is publishing a  
18 consultation last year which proposed a series of proposals on fusion  
19 regulation in the U.K. We've got 58 responses from around the world on this  
20 and we published our response to those responses in June. What I will do  
21 now is very briefly talk you through those bits of work to hopefully give the  
22 Commission a sense of the big themes that we considered in the U.K. Next  
23 slide, please.

24 The aims of that consultation, which are really important, are

1 to look at where the existing regulatory framework would be appropriate and  
2 fit for purpose for fusion energy facilities. It's not about developing a new  
3 framework but whether the existing one works and what changes may need  
4 to be made as the technology matures. Next slide, please.

5           The objective of that exercise, safety is paramount but of  
6 course, proportionality is really important and I will explain how we appraise  
7 that proportionality question in our work. Transparency and innovation are  
8 also really important for the U.K. Government on this, recognizing that the  
9 sector is increasingly diverse so innovation is going to be really important for  
10 the commercialization of fusion. Next slide, please.

11           Very briefly, the way it currently works in the U.K. is that,  
12 broadly similar to the NRC byproduct materials approach, simplistically  
13 speaking perhaps, in the U.K., rather than the Office for Nuclear Regulation  
14 regulating fusion, R&D, it is regulated instead by the Health and Safety  
15 Executive and the Environment Agency in England. There are different  
16 regulators around the whole of the U.K. A really important thing to note is  
17 that the goal-setting approach, the way it works in the U.K., we think that works  
18 well for diverse sector, employing lots of different technologies, and those  
19 technologies maturing as they are at increasing pace, that goal-setting  
20 approach is really helpful for that. Next slide, please.

21           When appraising proportionality we looked at the hazards,  
22 very similar to the work that you're currently doing. Obviously, the safety  
23 assessments that are out there are increasingly outdated, but they  
24 nonetheless remain really helpful in determining bounding scenarios.

1                   The uncertainties around inventories and things like that  
2 mean that we have to take very conservative assumptions but nonetheless we  
3 think that there is enough evidence and enough analysis out there to arrive at  
4 meaningful conclusions.

5                   The other thing I should note, as referred to on this slide, is  
6 that the radiological hazards are really important but they're not the only ones  
7 to take into account and we're confident that certainly, in the current  
8 framework and with the current activity in the sector, that works well. Next  
9 slide, please.

10                  The accident scenarios that I referred to there, a lot of this  
11 is detailed online in the U.K.'s public energy authority's technology report.  
12 This is in fact referred to in some of the NRC materials, which is really good.  
13 I'm not going to go into any of this detail online because we don't have time.  
14 If anyone, I should add, from the Commission or anyone else wants to pick up  
15 some of the detail, we're very happy to do that. Next slide, please.

16                  The conclusion of that is that our work was quite clear that  
17 we should maintain the existing regulatory approach and perhaps learning a  
18 little bit from the way that fission is regulated through things like design-stage  
19 engagement, perhaps introduce those to that framework. But broadly, the  
20 changes we would need to make are about building regulator capability and  
21 ensuring clarity in the regulations, rather than fundamental change. Next  
22 slide, please.

23                  The majority of respondents agreed broadly with that. Next  
24 slide, please. Some important points raised about the need to perhaps be

1 even more conservative around our conclusions given the uncertainties  
2 associated with the technologies and the increase in hazard. We're confident  
3 that actually, hazard is going to increase but is not going to fundamentally  
4 change, as we've heard elsewhere and that, therefore, is not warranted to  
5 change in regulator. The increasing capability and capacity is really  
6 important but we're confident that the regulators can do that. Next slide,  
7 please.

8                   So, that led to the decision, as published in June, that we  
9 will indeed be regulating fusion energy facilities in the U.K. under the existing  
10 legal framework. There's plenty of commentary on all of the thinking behind  
11 this in the publication document in June. And the introduction of new  
12 provisions to enable that to happen is already underway. Next slide, please.

13                   This just confirms this approach will apply to all currently  
14 planned fusion facilities in the U.K. But as that bottom bullet point shows the  
15 Government is, of course, prepared revisit its decision, if compelling evidence  
16 is presented to show that the hazard as currently projected would be far  
17 beyond that, as we have already assessed. Important to note. Next slide,  
18 please.

19                   We are already preparing to put those findings into law to  
20 clarify the existing nuclear regulations, which although currently, again, do not  
21 apply to fusion, the wording is such that we think some amendments will help  
22 really reinforce that to clarify. Next slide, please.

23                   I'm not going to go through all of these things but I think it's  
24 important for the Commission to note that in the U.K. we're also looking at



1 many of the other secondary issues such as planning, liabilities, export  
2 controls that fusion developers will need to get assurance of as they progress  
3 their technologies. Next slide, please.

4 There are even more of those issues to work through. Next  
5 slide, please.

6 The final point is that the U.K. is working with agencies such  
7 as the IAEA and through networks such as Agile Nations to share best  
8 practice, our findings, look at the important principles that we think others  
9 should look at when considering this topic. Next slide, please, I think it's the  
10 final one.

11 Excellent, those are my links, they're all in the slides already  
12 shared, please do check those out. I hope that's been a helpful overview of  
13 what we're doing in the U.K. Thanks again for inviting me.

14 CHAIR HANSON: Thank you very much, Mr. Edward-  
15 Smith, that was very helpful. Next we'll learn from Megan Shober, she's a  
16 Nuclear Safety Specialist with the Wisconsin Department of Health.

17 MS. SHOBER: Thank you. Good morning, my name is  
18 Megan Shober and I'm here representing the Wisconsin Agreement State  
19 Program. Next slide.

20 This graphic illustrates how radiation sources are currently  
21 regulated. In the green box, states have authority over electronic sources of  
22 radiation including accelerators, and in orange, the NRC regulates special  
23 nuclear material via 10 CFR Part 50. Radioactive material in blue is regulated  
24 by agreement states under a 10 CFR Part 30 framework. And in NRC space,

1 that Part 30 authority is limited to byproduct material.

2 Fusion systems are built on an accelerator and involve  
3 radioactive material as targets or activation products. Agreement states  
4 already have the statutory authority to regulate both the accelerator and any  
5 radioactive material that's contained in a fusion system. Our definition of  
6 radioactive material, which is broader and much simpler than NRC's definition  
7 of byproduct material, comes from the Conference of Radiation Control  
8 Program Director's suggested state regulations. Many states use versions of  
9 this definition and similar to Wisconsin, already have a framework to license  
10 fusion systems, without the limitations with NRC faces with respect to its  
11 definition of byproduct material. Next slide.

12 States have been regulating electronic sources of radiation  
13 for decades and in Wisconsin, our authority dates to 1972. In Wisconsin, all  
14 accelerators require radiation machine permits and accelerators that use or  
15 produce tritium or neutrons require a radioactive materials license. My  
16 program has issued radioactive materials licenses for both deuterium-  
17 deuterium and deuterium-tritium fusion systems for both research and  
18 commercial uses. These licenses include a full-scope radiation safety  
19 program, effluent monitoring, financial assurance, and consideration for  
20 emergency planning.

21 In 2009, we issued an R&D license for a small fusion device.  
22 In the mid-2010s, our licensee diversified the applications of their technology.  
23 In 2018, we licensed a fusion device with a tritium gas target, and in 2019 we  
24 licensed a neutron radiography device. We are currently reviewing

1 applications for upgraded equipment including an advanced tritium handling  
2 system and we expect these systems to continue growing larger and more  
3 complex over time. Next slide.

4                   So, what have we learned? We have had challenges along  
5 the way but the most pressing challenges can be solved. Our key needs right  
6 now are training our staff and developing fusion licensing guidance. Since  
7 NRC has very little experience with fusion-related issues, we are building  
8 connections with experts in industry, academia, and the DOE. We have an  
9 urgent need for guidance to evaluate tritium handling practices and inventory  
10 control, and for the size and scope of environmental monitoring.

11                   We also need resources for evaluating credible accident  
12 scenarios. Fusion applicants want to use a dose calculation to demonstrate  
13 that an accident would result in a dose less than the threshold for requiring an  
14 emergency plan but NRC's emergency planning guidance in Regulatory Guide  
15 3.67 unfortunately offers little for assessing the dose calculation route.

16                   And finally, we have had issue, a few rule exemptions for  
17 fusion licensees. For example, the immediate reporting threshold for lost or  
18 missing tritium is 1 curie and for fusion licensees this level of precision on  
19 inventory control is impossible. Next slide.

20                   Over the past two years, there's been a lot of discussion on  
21 what fusion activities should or should not be licensed under a Part 30  
22 framework. It is critical for us to have jurisdictional certainty over the short  
23 and medium term for the fusion technologies that are being tested.  
24 Applicants want to be able to determine who their regulatory authority will be

1 and as we proceed with staffing and developing expertise writing guidance,  
2 we need to know these efforts will not be wasted.

3           Getting to regulatory certainty requires thoughtful, practical  
4 definitions and decision criteria for any Part 30-Part 50 boundary. Ever since  
5 the Nuclear Energy Innovation and Modernization Act passed, the lack of a  
6 definition for fusion reactor has concerned us. As have proposed Part 30  
7 boundaries that impinge on activities that states have successfully licensed,  
8 like large radioactive materials inventories and licenses with emergency plans.

9           In Wisconsin, we are invested in fusion and other high-  
10 neutron flux technologies. And we want to continue to maintain jurisdiction  
11 over the things that we currently regulate, both the accelerators and the  
12 radioactive materials licenses. Next slide.

13           From our vantage point, regulating fusion devices under a  
14 Part 30 framework is working so far. Part 30 includes needed regulatory  
15 mechanisms, like financial assurance and emergency planning. And we  
16 have been able to respond to the challenges. I can't speak to whether Part  
17 30 will work for every future fusion technology, but with small rulemaking  
18 modifications, we could better accommodate the foreseeable fusion activities  
19 and guidance would help streamline licensing until the fusion industry  
20 matures. To the extent that Wisconsin's experience can help the NRC or  
21 other states, we are happy to share what we've learned and I look forward to  
22 working with the NRC on these efforts as we are able. Thank you.

23           CHAIR HANSON: Thank you. Next we'll hear from  
24 Sachin Desai, who is the General Counsel at Helion Energy.

1 MR. DESAI: Thank you very much, Chairman Hanson.  
2 My name is Sachin Desai, I'm the General Counsel for Helion Energy. I spent  
3 my career working on nuclear regulatory matters, including starting at the U.S.  
4 Nuclear Regulatory Commission at the ASLB.

5 I want to first start by thanking the NRC staff for years of  
6 constructive engagement on this topic. We've had a very positive working  
7 relationship with the NRC staff and look forward to continuing that over the  
8 many years we deploy this technology. I'm going to use this presentation to  
9 overview a couple quick concepts and then point to materials in the record  
10 that might have a little more deep dive. Next slide, if you could put it up on  
11 the screen?

12 In the fusion community, I just want to note to start things  
13 off that we are here for one reason, which is the need for clean energy. We  
14 need to deploy a gigawatt a day of clean energy on the grid to meet our 2050  
15 milestones. And you have to do that in a manner that ensures energy  
16 security across the globe. The future community is ready to meet that  
17 challenge. There are 20-plus ventures in the United States alone working on  
18 fusion designs, across a diversity of technologies, that have raised \$4 billion.  
19 Those technologies and that funding has allowed us to meet and set some  
20 really ambitious mid-decade milestones for demonstrating our technology and  
21 then deploying in the early 2030s if not sooner.

22 Helion is an example of that community. We want to  
23 demonstrate net electricity from fusion in 2024 and in addition, we are actually  
24 also a great example of the diversity of technologies that are out there, as

1 opposed to some of the Tokamak concepts that have been discussed, we  
2 have a magneto-inertial concept. We form two plasma rings, we accelerate  
3 them towards the center, and then compress the final product. We want to  
4 use deuterium-helium 3 fuel and a pulsed process. Next slide.

5 I'll just add that our devices have been regulated by the  
6 Washington State as particle accelerators. So, there's a really urgent need  
7 to get the regulation of fusion right and the best place to start with that is the  
8 safety case. When we're looking between different framework options for  
9 how we want to regulate fusion, especially looking at existing options, the best  
10 thing to do might be to look at precedent. Our view, or at least my view, is  
11 that byproduct materials framework offers the best safety case precedent for  
12 regulating fusion devices.

13 So, in an August 2022 letter we get into much more detail  
14 about the regulation of fusion and its safety case, but just to highlight a couple  
15 quick points, operationally, fusion devices are very similar to particle  
16 accelerators in other industrial facilities. You might say, well, we might have  
17 certain expanded hazards, but they're not that different in kind. For example,  
18 medical electrons need meters of shielding to deal with much higher-energy  
19 neutrons that come off those devices. So, at the end of the day, the shielding  
20 requirements are quite similar and we discussed this in our March  
21 presentation.

22 In terms of off-normal incidents, one thing to bring out is the  
23 inventory on a device is actually quite limited. This is again discussed in a  
24 March NRC staff presentation. One example for Helion is we demonstrated

1 and discussed to the NRC staff that if we were to take an extreme example,  
2 we were to take our 50 megawatt plan device and essentially turn the entire  
3 vacuum vessel into dust and release it into the air, some of that I have to  
4 emphasize is beyond physically capable, the dose to the public at the  
5 maximum point is 11.3 millirem, or one-ninth the public dose limit. And the  
6 reason for that is fundamentally, the amount of radioactive material in a fusion  
7 device itself is quite limited because we don't have a whole core of radioactive  
8 material with years of inventory.

9                   Now, there are radioactive material concerns and hazards  
10 to address with fusion. For example, we produce tritium in our approach that  
11 we have to store safely, but that is fundamentally no different than how  
12 irradiators has to deal with millions of curies of radioactive material, how  
13 medical isotope generators have to very closely work with radio isotopes that  
14 they produced in particle accelerators or other industrial facilities.

15                   I wanted to spend most of the time on that slide, but we can  
16 get into more detail. Just to quickly jump to two other slides, as a nuclear  
17 attorney I hear a lot about how you classify fusion devices. Fusion has to fit  
18 in the AEA at the end of the day and there's no clear statement about fusion  
19 in the AEA. I'll just note in that August letter we get into more detail about the  
20 regulatory classification. One thing I'll just call out is a perspective. If we  
21 were to not think about fusion devices as energy generations, just say that  
22 fusion is a technology that we can use for multiple applications, we can switch  
23 out the deuterium helium-3 fusion fuel and put in deuterium-deuterium and  
24 make tritium and helium-3, a radioactive material that has commercial value

1 as well as helium-3, which has tons of different applications.

2           There probably would be no real question of that  
3 accelerator-driven process that produces byproduct material is under the Part  
4 30 framework. Now, if we switch out that deuterium-deuterium with  
5 deuterium helium-3, which actually has less radiological impact than  
6 deuterium-deuterium, why do we end up in a stricter framework? Think about  
7 that when we think of right-sizing our regulations and being consistent.

8           The last thing I want to touch on is about the capabilities of  
9 the Part 30 framework, that comes up in a lot of different contexts and  
10 discussions. In a June 7, 2022, presentation to the NRC staff, we basically  
11 asked a question, and admitted there are obviously issues we need to deal  
12 with, with any new energy technology, what are the things we want to police  
13 in a fusion device?

14           And so we went through them, access control, shielding,  
15 entering and exit, maintenance issues, decommissioning, emergency  
16 planning, materials security. And then we looked in the Part 30 paradigm,  
17 Part 30 is more than just one section and found that those tools exist in the  
18 Part 30 framework today. Under the regulations that exist for  
19 irradiator facilities in Part 36 you see a number of regulations that are  
20 applicable. And then in Part 30 you see a number of other capabilities.

21           In addition, one thing that's really exciting about the  
22 materials framework is its embracement of diversity and novelty. I really like  
23 to point to Part 35 as a great example of a capability that's inherent by  
24 addressing diversity in fusion device design or in radioactive materials. And



1 in Part 35, the materials framework, you have different subparts for different  
2 types of applications of radioactive materials for medical applications. You  
3 also have 35-1000, which is a unique process where if an innovative  
4 technology comes in the door, the NRC develops licensing guidance working  
5 with agreement states to deploy that technology. That type of different  
6 thinking is exactly why the materials framework is not just suited to fusion but  
7 uniquely capable of dealing with fusion as it scales.

8 To just conclude, fusion is game-changing energy  
9 technology that has hazards, but those hazards are akin to what you see in  
10 the materials framework currently and is used by other industrial facilities, as  
11 the U.K. speaker has pointed out. The materials framework has the tools to  
12 handle fusion today and over time. I would note that maybe in the near term  
13 there's a need to just reply to principles for case-by-case licensing. But when  
14 it comes time to develop our proper regulatory framework for fusion, those  
15 tools exist and can form the foundation for a strong regulatory framework  
16 going forward.

17 CHAIR HANSON: Thank you very much. Now we'll hear  
18 from Dr. Bob Mumgaard. He's the CEO of Commonwealth Fusion Systems.

19 DR. MUMGAARD: Thank you so much, I'm Bob  
20 Mumgaard, Ph.D. in plasma physics from MIT. I spent my academic career  
21 in fusion working in various sizes of machines and I also working on machines  
22 overseas.

23 About six years ago MIT asked a really important question  
24 of itself, which is what is its role in fusion and where was this going as a field?

1 There were companies that had spun out, there is the ITER project, strong  
2 academic routes, where is this going to go?

3 And the answer, after a concerted look, was that in order for  
4 fusion to make a difference in the problems that are the biggest for the nation  
5 and the world, it would have to become an industry, an entire industry, an  
6 industry at the scale that is the scale of other energy industries, a scale that is  
7 even larger than the existing fission industry.

8 How does it get there? It gets there one step at a time but  
9 never forgetting about where it's going, meaning we build devices but we're  
10 always looking to what is the next device. We train scientists but we also  
11 think about who is the public, how are they involved? How do we get ahead  
12 of any potential uncertainties, how do we get ahead of any potential backlash?  
13 And we build an entire system to be able to do that.

14 As part of that at MIT, Commonwealth Fusion Systems spun  
15 out in 2018. Commonwealth Fusion Systems is now the largest of all the  
16 private fusion companies. There's about 375 people that are employed  
17 directly by the company and about 1000 people that are working on its  
18 projects. It is commercializing, meaning not just doing science but thinking  
19 about how to build a fusion product, the Tokamak, which is by far the most  
20 studied fusion machine, a machine with roots in Princeton, Oak Ridge, ITER,  
21 GA, and a long history of 150 Tokamaks have been built.

22 And we go to the next slide and you'll see the trajectory of  
23 where Commonwealth Fusion Systems is today and where we plan to go.  
24 This mirrors the trajectory of many of the other fusion companies. As

1 mentioned, there's over \$5 billion invested in this space. They start with an  
2 idea of a science experiment. In our case, Alcator C-Mod on the left, that was  
3 a Tokamak at MIT regulated under the Part 30 framework, run by and funded  
4 by the Department of Energy.

5                   It reaches the conditions so that fusion actually happens; it  
6 makes many, many neutrons from fusion; it creates activated materials from  
7 fusion; it doesn't create a lot of power, it's not designed to do that, but it creates  
8 the power of the science that enabled us to know how ITER is going to work  
9 but also to know what we should build next. That's coupled with a key  
10 innovation, which is happening across this entire field, which is we found  
11 things that could drastically accelerate and change the topology of these  
12 fusion machines, in our case, a very strong magnet. There's other examples,  
13 AI, actuators. That strong magnet allowed us to build a next-step Tokamak  
14 that's 40 times smaller than we thought was previously possible, a machine  
15 we call SPARC.

16                   This is a machine that will produce copious amounts of  
17 fusion energy, meaning at any given time you push a button and it would make  
18 about 100 megawatts of fusion heat for about 10 seconds. That's a similar  
19 mission to what ITER is doing. That mission shows that fusion is feasible, it  
20 doesn't yet show it's practical. So, if we show that slide again, that machine  
21 is being built right now, we can show pictures of it.

22                   We're also looking to what the next machine is, a machine  
23 we call ARC, which is a Tokamak that you see the scale here, about 400  
24 megawatts of heat designed to produce commercial fusion power and

1 demonstrate this is a practical energy source that can scale. We are currently  
2 looking for where to build ARC today and ARC fits within the Biden  
3 Administration's decadal plan for showing a fusion pilot plant, an actual plant  
4 that's not just a demonstration of science, but a demonstration that this can  
5 make power repeatedly in a commercially relevant platform. If we go to the  
6 next slide?

7                   This is not some far-off thing that may or may not happen.  
8 This is happening today. Here are pictures of the SPARC facility in Devens,  
9 Massachusetts, about an hour west of Boston. This facility is about an \$800  
10 million dollar facility, it is fully paid for by the investors and Commonwealth  
11 fusion systems, which include large energy companies, large financial  
12 institutions domestically and foreign, large innovation-based venture  
13 capitalists. And this facility in the foreground is a concrete shielded hall,  
14 inside there's a Tokamak, underneath there is a tritium handling system, and  
15 in the background is a magnet factory to make more of these facilities.

16                   So, if we go to the next slide. We, like other people on this  
17 panel, agree on the hazards that fusion poses, which are primarily related to  
18 what are the materials and where are they, the tritium irradiation, and is the  
19 machine on or is the machine off? Like other fusion machines, they all have  
20 very small amounts of fusion fuel inside them, you can't build a fusion machine  
21 that has lots of fusion fuels, it's physically not relevant. And so at any given  
22 time, a tiny bit of fuel is inside the machine producing a lot of power and when  
23 you shut it off you're left with activated materials in a fuel cycle.

24                   Those systems are systems that look like accelerators

1 today, they look like things that are already regulated today. They're slightly  
2 modified, maybe they are scaled up but in character they are not different.  
3 And we all demonstrate those at a small scale, low throughput in SPARC the  
4 same way that ITER is doing it, the same way that JET and TFTR has done  
5 it, but we need to know where we're going to go for ARC and we need to know  
6 that relatively soon.

7                   These investors who are looking at the challenge of climate  
8 change, there is over a \$100 trillion energy transition that needs to happen to  
9 get to a sustainable carbon-free net-zero by 2050 and they're saying what are  
10 other technology mixes that are going to be able to be successful? And the  
11 attributes of success come from the fundamentals, in our case, the  
12 fundamental fusion reaction which is fundamentally different than the fission  
13 reaction. No uranium, no plutonium, no chain reaction, no splitting the atom,  
14 no transuranics, which means the approach and the acceptance of this could  
15 also be fundamentally different, meaning it could be a technology that could  
16 get widespread adoption. And it could go much faster than we previously  
17 thought.

18                   That's if we get it right and we don't have to get it right  
19 forever, but we do have to get it right for right now, which is, yes, SPARC,  
20 that's going, that's understood, but what does that fusion pilot plant look like  
21 and how do we get that on the grid within the early 2030s? That means we  
22 have to make decisions about what that looks like basically in the next two  
23 years. And that's a global decision that almost all these companies are facing  
24 and so I really look forward to this conversation as all the technical pieces

1 have come out and we can put it context and also look at the different pros  
2 and cons of different options that have been put into the very diligent work by  
3 the NRC Staff. Thank you.

4 CHAIR HANSON: Thank you very much. We'll finish up  
5 with our external panel this morning with Mr. Seth Hoedl, he's the President  
6 of the Post Road Foundation. Mr. Hoedl?

7 DR. HOEDL: Good morning, can you hear me?

8 CHAIR HANSON: Now we can.

9 DR. HOEDL: Thank you so much. Good morning,  
10 Commissioners, and thanks so much for the invitation to present today.  
11 Apologies that I can't be there in person. My name is Seth Hoedl and I'm  
12 President and Cofounder of the Post Road Foundation. It's a nonprofit  
13 dedicated to helping underserved communities build sustainable  
14 infrastructure.

15 To give you some background, I'm originally trained as an  
16 experimental nuclear physicist, which I pursued both in academia and as an  
17 executive in radiation ecology startup. I'm also trained as an energy law  
18 attorney. As part of my work at Post Road, I think of how new energy  
19 technologies can be deployed in ways that meet community needs. From an  
20 academic perspective, you might think of this work as energy ethics. From a  
21 commercialization perspective, you may think that it pertains more to public  
22 exceptions or social license. I've applied this thinking to nuclear technologies  
23 including fusion in a variety of peer reviewed publications and it's this work  
24 that forms the basis of my talk today.

1                   The perspective that I'd like to introduce you to in this  
2 briefing is that early public engagement, even in this process of developing a  
3 regulatory framework, is essential to build public trust in the fusion industry  
4 and eventual regulation. Without such trust, fusion will struggle to achieve  
5 the full potential impact on climate change, global energy poverty, our nation's  
6 economic competitiveness, and our nation's national security. Next slide,  
7 please.

8                   Fusion has the potential to be a transformative technology  
9 but it won't be easy. In order to achieve impact, the technology will have to  
10 work, be economically competitive, have regulatory approval, a scalable  
11 supply chain, a trained workforce, and underlining all of these ingredients,  
12 public acceptance.

13                   While it's possible that the achievement of burning plasma  
14 is such a great accomplishment that it paves that way for wide adoption, it's  
15 not guaranteed. And this isn't a new observation. In 1994, EPRI listed  
16 social acceptance as one of the three key ingredients for practical fusion  
17 power. Next slide, please.

18                   The reason public acceptance is so important for fusion's  
19 impact is that energy technologies that don't have public acceptance stall.  
20 They don't achieve their full potential and I represent that here on this graph  
21 on the left side of this slide, where technologies that do have public  
22 acceptance or social license, is they enter the marketplace that follow this red  
23 curve. They grow up and they plateau at a relatively high level. There are  
24 technologies that lack public acceptance or that don't have a social license.

1 They follow this blue curve. They do enter the marketplace but they plateau  
2 at a much lower level. And the reason for this difference is that technologies  
3 that don't have public acceptance have a higher cost of capital and higher  
4 capital cost, they increase litigation risks and costs, and they face increased  
5 regulatory burdens.

6 We see these effects in a variety of energy technologies, we  
7 see this with transmission lines, we see it with windfarms in a variety of  
8 contexts, and perhaps most pertinent for this panel, we see it with nuclear  
9 fission. Fortunately, fusion is so young that it can distinguish itself from these  
10 technologies, not just in a way that uses physics but also in a way that  
11 approaches society. It can follow the red curve, it doesn't have to follow the  
12 blue curve and have impact. Next slide, please.

13 Also, fortunately, there are established methods for  
14 achieving public acceptance and these methods are easier than achieving a  
15 burning plasma; namely, social license, ethical review, and responsible  
16 research to innovation. These methods all have insights for fusion.  
17 Importantly, these methods go far beyond a scientist's or an engineer's default  
18 approach to public acceptance, which typically focuses on technical change,  
19 complying with regulation, and engaging in better communication or  
20 education.

21 It's been remarked for over forty years, these approaches  
22 on their own are unlikely to facilitate public acceptance, more is needed and  
23 that's what these methods provide. Next slide, please.

24 The social license is the most prescriptive method and so I



1 want to highlight some of its elements here. It's really a process of  
2 meaningful engagement, it opens expertise to new questions and  
3 perspectives and addresses what people actually worry about rather than  
4 what they should worried about. It engenders trust, it's transparent, it  
5 protects human health and safety, and it's more than education, public  
6 relations, or letting the public see the experts at work.

7 I want to note that protecting human health and safety is  
8 essential, in some sense the motivation for this briefing, but it's only one of the  
9 six elements that are needed with the social license method to achieve public  
10 acceptance. The process of securing human health and safety, if it doesn't  
11 engage the public sufficiently, then the fact that the public health and safety,  
12 that fact alone will not be enough to achieve public acceptance. Next  
13 slide, please.

14 You can think of the social license method as an iterative  
15 two-way conversation between technology developers and the public. And  
16 this iterative process both builds public acceptance and strengthens  
17 outcomes. It identifies problems that experts miss, it's sensitive to social and  
18 political values that experts may not share, and it creates a sense of  
19 procedural justice and a positive feedback loop that enhances trust.

20 It only works if the public trusts the industry and government  
21 regulators that ensure the public safety. If there's no trust from the beginning,  
22 conversation goes nowhere, public acceptance never happens, and the  
23 energy technology stalls.

24 I don't think the NRC should be responsible for this two-way

1 conversation or for fusion to achieve public acceptance. But the NRC does  
2 have a critical role to play in building trust in fusion and fusion's regulation  
3 during this very early phase of fusion's development. Next slide, please.

4                   Bringing these insights into the topic of the briefing today,  
5 the public needs confidence that the NRC adopts a regulatory framework that  
6 has the authority to manage the full range of risks that concern the public.  
7 Then there's an accident and fingers crossed, it's a very small accident. The  
8 public needs confidence that the NRC and the industry didn't overlook risks  
9 when developing the regulations. If the public comes to believe that shortcuts  
10 were taken, it will undermine trust in the industry and the regulators to the  
11 detriment of the long-term viability of fusion.

12                   Of course, the regulations themselves need to have such  
13 authority in order to work, but the process by which the regulations are  
14 developed is equally important. That process needs to be transparent, based  
15 on the full range of risks that concern the public, and undertaking meaningful  
16 public engagement.

17                   Just a few final thoughts on potential practical steps. First,  
18 actively solicit public concerns from communities nationwide, not just public  
19 meetings like today's. Today's is important but more needs to happen. This  
20 solicitation will be expensive, it will be time-consuming, but it will be worth it in  
21 the long-run for fusion's viability.

22                   Second, on the basis of this solicitation and also expert  
23 input, address the concerns that are identified through a transparent high-level  
24 health and safety analysis, perhaps before selecting regulatory framework.

1                    Opaque expert-only assessments and regulatory choices  
2 are likely to be counterproductive. Use this analysis perhaps to make a  
3 catalog of risks that the regulatory framework needs to address to satisfy  
4 experts and the public, and then transparently craft the regulatory framework  
5 to manage these risks.

6                    Third, support independent health and safety assessments.  
7 This point is more to the fusion industry has made to the NRC but it never  
8 hurts to have a second opinion on the risks that fusion might pose and the  
9 strength of a regulatory framework to manage those risks.

10                    To summarize, the degree to which the public is  
11 meaningfully engaged in the development of the regulatory approach and the  
12 eventual licensing of fusion reactors, whether through Part 30 or otherwise,  
13 will have a profound impact over long-term public trust in and public  
14 acceptance of this technology. Public input is essential, even at this very  
15 early stage. Thanks for your time.

16                    CHAIR HANSON: Thank you very much, Mr. Hoedl. We'll  
17 begin this morning with Commissioner Crowell, but before we do, I'll note that  
18 we've got a really large panel here so if my colleagues need to take a little  
19 extra time, they should feel free to do so.

20                    COMMISSIONER CROWELL: Thank you, Mr. Chair, and  
21 thank you to all the presenters today. This has been extremely informative  
22 and it appears to be an exciting time for fusion and we've been waiting a long  
23 time for this.

24                    Dr. Hoedl, I really appreciate your presentation, I'm not

1 going to ask you any questions other than to say I agree with you and I think  
2 a point you made that the public needs confidence that the NRC and other  
3 regulators adopt a regulatory framework that has the authority to manage the  
4 full range of risks that the public cares about is critically important in this  
5 process. The public does not appreciate the difference, every person does  
6 not appreciate the difference between fusion and fission, they just see it as  
7 nuclear and then that comes along with a host of impressions based on your  
8 experience with nuclear in the past, be it weapons, fission, other uses of  
9 nuclear. So, we need to keep that in mind as we move forward.

10 I'm going to ask Dr. McCarthy first and I'm sure someone  
11 else will want to chime in here as well, but what makes this discussion about  
12 fusion today different than the one we've had over the last 10 years, 20 years,  
13 50 years? Because we've all heard it before but I feel like we're more on the  
14 precipice this time than in the past, but I couldn't articulate that. So, if  
15 someone could help with that, I'd appreciate it?

16 DR. McCARTHY: I'd be happy to do that. I went into  
17 fusion in graduate school, which was quite a long time ago and at that point,  
18 there was a lot of research going on, but there wasn't really the energy around  
19 it that there is right now.

20 Why is that? We have seen results from recent  
21 experiments in the joint European Taurus, prior to that in the Tokamak fusion  
22 test reactor, which actually did deuterium tritium shots that were predictable  
23 with the codes. That's a very important thing as well. We've learned a lot in  
24 terms of modeling and simulation and our ability to predict has gotten quite a

1 bit better. That gives us confidence in terms of maintaining and controlling a  
2 plasma.

3 We are also seeing progress in terms of assembly of the  
4 ITER project. We're developing an industry, we're able to write specifications  
5 the industry can deliver on that will meet the French regulator requirements.  
6 So, that's another piece of it. You also see investment by private industry,  
7 that's new and you saw that on the chart. Private industry will typically look  
8 for things that give them a return on investment. I think that's a really  
9 important indicator that there's really important things that are coming out of  
10 fusion, ultimately clean fusion energy. So, I think those are some of the  
11 reasons why.

12 COMMISSIONER CROWELL: Mr. Desai or Dr.  
13 Mumgaard, do you want to chip on this?

14 DR. MUMGAARD: Kathy's exactly right, there's a scientific  
15 basis that's been established and you can't underestimate that but on the other  
16 side of this too is there's a saying, when will fusion be ready?

17 It'll be ready when the world needs it and we've developed  
18 this science but now we've seen the pull-down, the reach-down to pull that  
19 science up from investors and for other people, saying now is the time  
20 because of climate, because of the energy transition, because the other  
21 technologies that have gotten so much better that have never been applied to  
22 fusion.

23 And I think also an additional point is you're seeing a  
24 changeover in the field. You have entirely new people coming into the field.

1 CFS is 375 people. Only about 10 percent of that came from fusion, all the  
2 other people came from other fields, they came from launching rockets, they  
3 came from building biotech, and came from manufacturing electric vehicles.  
4 Because fusion can have a very, very big difference in the world, it's attracting  
5 talent, it's attracting ideas, it's attracting a diversity of viewpoints, it's attracting  
6 new technologies. And that centralizing function is hard to put your finger on  
7 but it's easy to feel when you go to a fusion conference today and compare it  
8 to where it was 10 years ago.

9 MR. DESAI: I'll just quickly add that in the case of the  
10 Helion example, it's a story about enabling technologies. Our approach to  
11 fusion fundamentally was thought of in the 1980s. There are black and white  
12 pictures we have in some of our slide decks about formation of FRCs and  
13 acceleration. However, we couldn't do this approach in the 1980s, we  
14 needed high-power semiconductors. We actually needed fiber optic cables  
15 in order to send the signals to the different magnets in time.

16 What happened actually, it's been kind of an unsung hero  
17 about fusion's advancement is a series of advancements in enabling  
18 technologies over the past 20 years that have indirectly, then substantially  
19 contributed to the growth of fusion. Now we have fiber optics, now we have  
20 power semiconductors that can send currents to our magnets in sufficient  
21 energy to cause fusion to happen and now we have modeling, now we have  
22 high-power magnets and other things that weren't there 20 years ago that are  
23 there today. That's brought a lot of exciting physics concepts that were put  
24 to the side 20 years ago and made it possible to do fusion today.

1                   COMMISSIONER CROWELL: Thank you all for that  
2 response. I think it also highlights that what was known about fusion from a  
3 scientific perspective and a regulatory perspective 20, 30 years ago was  
4 different than what we know 10, 20 years in the future is going to be different  
5 than what we know now and that is why we need to have a nimble, adaptive  
6 framework that prioritizes safety, but also is manageable from the industry  
7 perspective to navigate.

8                   And I think that's going to be an evolution and as long as  
9 there's willingness to evolve with the technology and with the learning curve,  
10 then this will end up in the right place but that needs to be kept in mind as we  
11 move forward.

12                   I'm a little concerned about some of the differences of  
13 opinions I've read about regarding the waste profile of fusion technologies and  
14 I would like any of you, and maybe this is a DOE question or an Oak Ridge  
15 question, I'm not sure who is best to answer this, but there seems to be  
16 different opinions as to whether it's long-lived waste or short-lived waste,  
17 whether it's high-level or non-high-level. And I think that's important to  
18 understand and have a grasp of from a regulatory perspective and in ensuring  
19 safety for the public now and in the future. I don't know who wants to take  
20 that one first.

21                   DR. McCARTHY: One of the things with fusion that we're  
22 able to do is, to some sense, decouple the structural material from the plasma  
23 itself. It's not quite that simple, but I mentioned in my opening remarks about  
24 low-activation materials.

1                   First of all, it depends on which fuel cycle you choose. A  
2 deuterium-tritium fuel cycle produces 14 MeV neutrons. There are other fuel  
3 cycles under development that would produce fewer and in some cases close  
4 to zero.

5                   So, a lot of it depends on that. I would also say with each  
6 of these fuel cycles, there's challenges, none is the clear winner. For  
7 example, with the deuterium tritium fuel cycle producing 14 MeV neutrons,  
8 something has to stop those neutrons and that is the structural material. So,  
9 if you're looking at, for example, steels, you can get some longer-lived  
10 activation products, not talking about transuranics, but it could potentially be  
11 greater than Class C in the current definitions.

12                   There has been a lot of work previously, it's slowed down a  
13 bit, it had slowed down a bit when the Department of Energy really pivoted to  
14 the underlying science program for fusion, now we've got to look at technology  
15 because we don't necessarily have clear winners. We don't have a clear  
16 winner in terms of materials and fuel cycle and that's important for commercial  
17 fusion. So, these low-activation materials potentially could activate less and  
18 that would impact what the waste is.

19                   So, your question has to be answered on a case-by-case  
20 basis and there are actually multiple papers that have looked at this sort of  
21 thing and I believe there's something coming out in Nuclear News specific to  
22 fusion waste that I think will be useful as well as well. It really depends on  
23 the specific technology chosen.

24                   MR. DESAI: I may add, one thing that's interesting about



1 the Part 30 framework is that it does have decommissioning financial  
2 assurance requirements and in many ways are actually stricter than what you  
3 would see in the utilization facility framework. And under the utilization facility  
4 framework, licensees can put money into a trust over time to meet anticipated  
5 future requirements. Generally, under much of the Part 30 framework,  
6 licensees have to post financial assurance at the start.

7           So, talk about a public trust mechanism, we have to actually  
8 put in the money to deal with long-term waste. We don't have long-term  
9 waste but the long-term decommissioning profile at the start. That's going to  
10 be a really powerful driver over time to make sure that we keep our waste  
11 profiles as limited as possible and to build public trust that no matter what  
12 waste we do produce with future companies, we're going to actually have the  
13 money set aside at the start of operations to deal with it.

14           DR. MUMGAARD: I would add a conceptual framework  
15 around this. In a fission system utilization facility, the waste is inextricably  
16 tied to the fuel. It literally is the product of the fuel. You have uranium, it splits,  
17 you have fuel rods with transuranics in it. That's what we call the waste. You  
18 don't actually call the activated materials in a fission system the waste.

19           In fusion, as Kathy said, they are completely decoupled.  
20 The fusion process itself has no nuclear waste, it makes helium, but what you  
21 choose to build the machine out of, that gets hit by neutrons and gets changed,  
22 becomes radioactive, and you have the choice of what materials to put in  
23 there. So, you have intrinsic trade-offs. If you put materials in that are  
24 higher-performing economically but maybe have a longer lifetime of

1 radioactivity.

2                   The key thing is it's a choice and it's a choice that will change  
3 with time, meaning the materials we have today are unlikely to be the materials  
4 we'll use in the future.

5                   And so often times it can look like a disagreement about the  
6 character of the problem, it's actually a disagreement about the timing of the  
7 solution, meaning the thing you build today produces X amount of waste if you  
8 build it this way like ITER or like DEMO. Versus no, the plan is to build  
9 something that's a bit different, it's a different material with a different volume  
10 in it because we have the ability to do that now and also, in the future we have  
11 the ability to develop new materials. Nothing precludes that, we just haven't  
12 worked on it that would be even different.

13                   And so that's one of the reasons we need a flexible system  
14 that looks at these activated materials as not a prescriptive solution but as an  
15 incentive solution that says let's get less and less and less of these as we go.

16                   COMMISSIONER CROWELL: Thank you. Mr. Chair,  
17 one more question, if possible? The other area that gives me a little bit of  
18 concern as I read more about fusion is the risk profile and the differences of  
19 opinion that I see from different parts of industry and academia and  
20 Government on the safety risk associated with fusion. And I think in terms of  
21 managing public acceptance of fusion, we need to sort that out quickly and  
22 clearly because if we don't have trust that we're managing safety  
23 appropriately, then we're sunk from the start.

24                   Perhaps Dr. Hawryluk or Mr. Lewis-Smith can comment on

1 this, but I was reading in the Advisory Committee on Reactor Safeguards letter  
2 that there's some inaccuracies in the NRC staff White Paper with regards to  
3 the safety risks associated with commercial-scale fusion, specifically citing  
4 DOE report from I don't know when, maybe even as far back as the '90s and  
5 some international studies on the safety risk. I was wondering if someone  
6 can comment on that?

7 DR. HAWRYLUK: I'm glad to comment on that and have  
8 others comment further. If you read carefully a lot of the studies, what you  
9 realize is that it depends strongly upon the level of safety barriers and what  
10 people do as far as engineering controls.

11 On TFTR, we had 2.5 grams of tritium in process, 5 grams  
12 on site; ITER is going to have 4 kilograms. In both cases, very detailed safety  
13 analysis indicates there was no emergency planning required. But you go,  
14 well, what's the difference? You've got almost a factor of 1000 difference in  
15 the tritium. And the answer is engineering controls, the safety protocols, the  
16 segregation of tritium, and these are the underlying engineering assumptions  
17 that they place which have to be taken into account in the detailed engineering  
18 design and how you handle the tritium.

19 There's plans underway to come up with ways to reduce the  
20 tritium inventory for future machines. There's plans underway to deal with  
21 maybe using alternate fuels when you don't have as much as tritium or any  
22 tritium on site. But this has to be done carefully, but it can be done, an  
23 experience we've had ranging from TFTR, JET, and ITER shows that it can  
24 be done but it has to be addressed consistently and thoroughly in your

1 regulations and in your engineering practices. Thank you.

2 MR. LEWIS-SMITH: If I may comment? I will briefly  
3 mention just a couple of points to add to that. The work the U.K. Government  
4 has done with its technical advisors to arrive at accident scenarios is very  
5 much based on bounding scenarios. It is not a definitive assessment of  
6 fusion risks or fusion hazards, it's very much, as I said, a bounding scenario  
7 to arrive at worst-case estimates and everything the previous speaker just said  
8 absolutely is applicable.

9 The other thing I would say when we're talking about safety  
10 implications is something that our work tried to do, which is invite comparison  
11 or at least talk to a potential accident, a very, very worst-case accident, let's  
12 say a very large chemical plant. We talk a lot about radiological implications  
13 of accidents on humans and the local environment, but it's important when  
14 we're talking to the public, that we'll associate fission with fusion to also  
15 conceptualize fusion within the broader industrial hazard context. Of course,  
16 there are very specific radiological implications but nonetheless, I think if we  
17 don't be a bit more holistic when we talk about safety, we run the risk of  
18 confusing people.

19 COMMISSIONER CROWELL: Thank you. Mr. Chair.

20 CHAIR HANSON: Thank you, Commissioner Crowell. I  
21 want to pick up on this theme that Commissioner Crowell introduced. But  
22 before I do, first of all, I want to say thank you to everyone for your  
23 presentations. It was very informative and also a very diverse set of views.

24 I guess I want to pull the thread on a couple of things that I

1 saw in the material around the DT fuel cycle and the technology around that  
2 and risk analysis and so on and so forth. I agree with the overall tenor that  
3 it's important to come up with a framework here that provides enough  
4 predictability for technology developers to proceed through their work in the  
5 next 5 to 10 years, but also is transparent and ensures safety and so on and  
6 so forth.

7 I take seriously the comments I think, Ms. Shoher, you gave  
8 us about Part 30, that Mr. Desai, Mr. Mumgaard gave us about Part 30, and  
9 yet, I think about these devices in almost a Part 50. I still keep coming back  
10 to almost a Part-50-type framework in terms of accident analysis and so on  
11 and so forth.

12 In some of the materials we got there was a paper included  
13 by Hersch, et. al., that referenced superconducting magnet failure. But there  
14 wasn't a lot of context in here about how that works and what magnet-  
15 crunching really is and what the results of that are. We all know when we  
16 look at risk there's the probability of that and then there's the consequence,  
17 the likelihood and then the consequence of that. And it's not a criticism of the  
18 paper at all but I'm hoping we can start, Kathy, with you and then proceed  
19 through others to explain what this phenomenon is, how often we've seen it,  
20 et cetera.

21 DR. McCARTHY: Superconducting magnets, and of  
22 course, I'm talking about magnetically-confined fusions, depending on the  
23 design have a significant amount of stored energy. And let me go to what  
24 we've seen as we've been testing the central solenoid modules at General

1     Atomics in California. So, there we have had a situation where we've had a  
2     quench which dumps a significant amount of energy, it has to go somewhere.  
3     So, what that means is you have a potential energy source that could mobilize  
4     radioactive material.

5                     Let's talk about Tokamak dust. One of the things, and I  
6     think it's mentioned in the ACRS paper, I think the staff talk about it as well,  
7     back when I was in Idaho in my early career, that was with the Fusion Safety  
8     Program and one of the things we did is we looked at Tokamak dust. We  
9     collected dust from all over the world and analyzed it. So, what your first wall  
10    is made of, what the plasma sees is what will be in the dust. Some plasma-  
11    facing surfaces absorb tritium, so in addition to the activated material, you can  
12    have tritium. That dust can be very fine and it can be mobilized. So, when  
13    we talk about the potential for a quench, that's what we're talking about. So,  
14    there's actually a code that was developed back in Idaho and I can't remember  
15    the name of it but looked at several of those scenarios.

16                    So, again, it's just an important thing to consider in terms of  
17    when you're evaluating the risk, and details can be found in those early papers  
18    but it's something that has been looked at. And the one final thing I want to  
19    say is you can't completely decouple the plasma from the material, the  
20    plasma-facing material because there are interactions because the two and  
21    certain plasma-facing materials can pollute that plasma. And then you lose  
22    confinement.

23                    CHAIR HANSON: Dr. Hawryluk and then Dr. Mumgaard?

24                    DR. HAWRYLUK: Just a brief comment, the issue that

1 Hersch raises about a quench releasing helium was actually looked at in the  
2 EAR safety case. So, this is a known thing, it's been analyzed and addressed  
3 as part of that activity.

4 CHAIR HANSON: OK. Go ahead.

5 DR. MUMGAARD: We've quenched quite a few magnets.  
6 What happens is you have a magnet, it dumps its energy inside and the  
7 magnet itself gets hot, sometimes parts of it melt. That is very different than  
8 breaching confinement of the radiological material. Those are physically  
9 separate systems. The magnet is around the vacuum vessel but in order for  
10 a magnet to actually produce a breach of the vacuum vessel, that's not  
11 something I know of ever seeing or ever being seen in analysis or anything  
12 like that. I don't even know what the physics of that would be. But more  
13 importantly, that breach of that vessel is part of the bounding case for all of  
14 the other types of scenarios that we look at in a safety case. Independent of  
15 how you breach it, the fact is if you breach it, you get a certain radiological  
16 consequence, that's the thing to hit on.

17 CHAIR HANSON: So, that phenomenon can be  
18 engineered around as part of the system case and it's been evaluated as part  
19 of ITER.

20 Mr. Lewis Smith, just to pick up on what Dr. Mumgaard said,  
21 you had mentioned a goal-setting approach in the U.K. and then Dr.  
22 Mumgaard touched on this issue of a bounding analysis for accidents. I  
23 wonder if you could jump in here and talk about the extent to which you've  
24 looked at this and how you're accommodating that within your framework?

1                   MR. LEWIS-SMITH: Sure, I was going to say on the  
2 quencher, yes, again this was raised in our consultation exercise and as Dr.  
3 Mumgaard just said, it is part of what sums up the bounding scenarios, if it is  
4 a contributing factor or not, that would be determined by the safety  
5 assessments the developer would have to do.

6                   In the context of a goal-setting approach, in magnetic fusion,  
7 for example, the developer would have to show the regulators in the U.K. what  
8 the potential consequences would be of components or systems failure and  
9 how they would mitigate them. The onus is there is then a degree of weight  
10 on the regulator to be able to understand that so that's why it's important, as I  
11 said in my presentation, to build technical capability in the regulator.

12                   But with that technical capability, that regulator can then  
13 say, yes, you've mitigated that risk to as low as reasonably practicable and in  
14 the context of the worst-case bounding assumption, the bounding scenarios  
15 of fusion, that is acceptable in terms of regulatory expectations in the U.K., for  
16 example. So, it is to show the regulator by assessing all of the different  
17 potential causes of accidents, they've been appropriately, sufficiently, and  
18 proportionately mitigated. It doesn't go into every single one and provide an  
19 example of how that should be mitigated, it's on the developer to explain that  
20 to the regulator.

21                   CHAIR HANSON: I see, thank you, very helpful. I  
22 wonder, Ms. Shober, if you could jump in and talk about this, again, goal-  
23 setting performance-based approach and what your experience is with that in  
24 Part 30?



1 MS. SHOBER: Just in terms of getting to things that are  
2 more complex?

3 CHAIR HANSON: Yes, that's a fine way to approach it, I  
4 think.

5 MS. SHOBER: The Part 30 framework is an additive  
6 framework. The Part 50 framework is set up where there's a whole structure  
7 and you're basically expected to fulfil all of these boxes and then you have to  
8 get exempted from things that don't match what you're doing.

9 So, Part 30 is the opposite tactic and you start out and  
10 there's a whole suite of tools that are available for regulators to exercise when  
11 necessary. And so for example, financial assurance, there's a threshold. If  
12 your possession limits are underneath that threshold, then we don't ask  
13 questions about financial assurance, we don't expect licensees to provide  
14 money for decommissioning.

15 Once you exceed, in that case, a certain possession limit for  
16 long-lived isotopes, then that trips the financial assurance trigger and then we  
17 look at decommissioning funding plans and we have those tools to incorporate  
18 in the license, those higher hazards.

19 Similar for emergency planning, there's thresholds, if you  
20 trip the threshold then you have to exercise those tools. So, I could foresee  
21 a similar sort of thing when we're talking about fusion technologies. When  
22 you enter in past some kind of threshold, then you have to exercise these  
23 other regulatory tools that are available.

24 CHAIR HANSON: That's very interesting, thank you. You

1 said something almost in passing as part of your presentation and I want to  
2 make sure I understand it and I don't want to mischaracterize what you said.  
3 But I heard, I guess, was Part 30 is sufficient, it provides reasonable  
4 assurance of adequate protection for now. Did I have that right?

5 MS. SHOBER: Again, I can only speak from the things  
6 we've already licensed and so no one has approached us with an application  
7 for a fusion energy system. So, our experience in our program, we don't have  
8 Ph.D.s in plasma physics on our staff. And so there's a process where if  
9 someone were to come in with an application, there's of course a period of  
10 time before that would actually come to fruition.

11 So, there is as learning curve that would need to happen,  
12 again, that's part of my hesitation in saying Part 30 is working for now and it  
13 may not work in the future. We don't know, we don't have that information  
14 yet. No one has approached us with an application for the superconducting  
15 magnets. That's not something that we have direct experience regulating.

16 Again, the framework is there, there are tools available for  
17 that, it's just not something that I personally have experience regulating. So,  
18 I don't want to cast a blanket over something that is beyond my expertise.

19 CHAIR HANSON: I thought actually it was an interesting  
20 point about adaptive or evolutionary regulatory frameworks.

21 MS. SHOBER: We do that all the time, we have a lot of  
22 complex licensees in Wisconsin that use accelerators, that generate high-  
23 neutron flux. It's not all fusion, we have other applications as well. And it's  
24 been a learning process with those licensees as well to find out the

1 complications with shielding design and the radioactive materials licenses are  
2 not really geared very well to represent the wealth of activation products.  
3 Because you can't measure them, they're all calculated, they're theoretical, so  
4 radioactive materials licenses, you have this many curies that you're allowed  
5 and for activation products it's based on a calculation.

6                   That's not very satisfying. As a regulator, how do you know  
7 how much possession you have? And so we've had to explore other ways of  
8 bounding those based on accelerator beam-on time. And so it is a challenge  
9 to figure out how to wrap our arms around that but again, we've been able to  
10 do that with the challenges we've taken on so far.

11                   CHAIR HANSON: I look forward to drawing on yours and  
12 others' experience as we go forward. Thank you. Commissioner Baran?

13                   COMMISSIONER BARAN: Thanks to all of you for being  
14 here and for your presentations. It is a great panel, I agree with the Chair  
15 about that. When I proposed holding this meeting a while back, it seemed  
16 like now was the right time to get an update on new developments in fusion  
17 and to continue the discussion about what the regulatory framework for fusion  
18 should look like.

19                   I think maybe I'll pick up with where the Chair left off, which  
20 is it sounds like there's quite a bit of support on the panel for a Part 30  
21 byproduct material approach for regulating fusion. I'm interested in whether  
22 the panel thinks there are any updates to Part 30 that are needed to tailor it to  
23 fusion systems.

24                   For example, would it help to include provisions about what

1 would be required for a safety analysis that considers the hazards from tritium  
2 or activated materials or plasma oil interactions or high-temperature  
3 conditions? What do folks think about that?

4 MR. DESAI: I'll take a crack at that. There absolutely  
5 need to be updates to any framework to adapt to a new technology. So, I  
6 would think of updates to Part 30, following an approach that scales over time.

7 To start things off, you're going to need a definition, it seems  
8 to be an important thing you would add, content of application requirements.  
9 That would just help provide certainty to regulators and then the applicants.

10 As well, there are things that have been voiced to us by  
11 states regulators about what they'd like to see and things they want to learn  
12 better, so tritium loss issues, tritium management issues, these are things that,  
13 again, states have had experience regulating a variety of isotopes but does  
14 want to know more about tritium.

15 So, maybe for the first licensees that can start off as  
16 concepts or guidance but I think over time you would want to develop a  
17 framework that is well tailored towards fusion. And then I think what we want  
18 to do there is just listen to the Staff and listen to the states to see what they  
19 want more clarity on and then we can tailor the framework to match that.

20 DR. MUMGAARD: In the spirit of creating some certainty,  
21 it's not just certainty on the side of the developers, it's certainty on the side of  
22 the regulators. So, in the case of agreement states, things like definitions  
23 that say, okay, this is what a fusion energy machine is, they could resolve  
24 some of the things Sachin actually showed earlier. If you do it for medical

1 isotope production and turn the machine on to then make heat that suddenly  
2 is different, we've got to resolve some of that from a definitional standpoint.

3           Also, I think one of the great things about the byproduct  
4 material framework, is that we get guidance, we can share lessons learned  
5 from states, there's good connectivity between those states, recognizing that  
6 basically every new applicant for the next ten years is going to be somewhat  
7 novel. And so let's not be prescriptive in advance, let's have those  
8 conversations upfront, identify what the guidance is, build that guidance up in  
9 the Part 30 framework, and then once we get some under our belt we can look  
10 at it again like we did for irradiators or like we did for well logging, or like we  
11 did for the other things. That's very different than deciding today we're going  
12 to put some big lines in the sand or we're going to leave it wide open. We  
13 have a system that's being used, it's accumulating expertise and with some  
14 coordination from the NRC and some transparency, and some tweaks, we  
15 think it can continue to work as we actually decide what is the future of this  
16 industry in terms of the types of plants to build?

17           MR. DESAI: I just want to go back to the Part 36 irradiator  
18 framework for example. There are a number of tools and regulations in there  
19 that are already quite tailored towards the types of issues we see with fusion  
20 devices.

21           And so to Bob's point, maybe you don't want to take that and  
22 spend all the work writing it down in a single framework today. But those can  
23 form the core concepts and the set of tools you would give as guidance to  
24 regulators for the first set of devices. And then as you see what works and

1 what doesn't work, you can use those tools as a foundation for a proper  
2 regulatory framework within the Part 30 paradigm.

3 MS. SHOBER: And I would add to that, state regulators  
4 are very comfortable operating from license guidance, that's something we  
5 use all the time with all of our radioactive material license types. And so I  
6 think definitely in the near term, it would be most beneficial for states to have  
7 those big-picture elements that would go into a fusion application, those would  
8 be better off in licensing guidance and not yet in the regulation.

9 COMMISSIONER BARAN: So, let me try to sum up what I  
10 think I heard on this. It sounds like in the near-term folks think Part 30 is  
11 pretty good for this but that as we're going forward, we're going to want to  
12 have tweaks, we're going to want to have more fusion-specific framework or  
13 module within Part 30 to lay this out. In the short term, it might be guidance  
14 that's more useful about content of applications or other things.

15 Is that how you all are looking at it? Given the significant  
16 uncertainty we have right now, which is pretty obvious, trying to do a rule right  
17 now wouldn't make a lot of sense, even for those tweaks. You hold off on even  
18 that piece until later, is that how you are looking at it?

19 MS. SHOBER: I think the one thing that does need to be  
20 clarified probably sooner rather than later are some of those really core  
21 definitions. Like I mentioned, fusion reactor, what is that? And you don't  
22 want scoop up things that are actually quite simple and force them into  
23 something that's just really not necessary for that kind of technology.

24 So, what is a reactor when it comes to fusion, those kinds of

1 questions need to get resolved sooner rather than later, and then some of the  
2 other details of specific facility kinds of things, those can come later on.

3 DR. McCARTHY: Yes, just very quickly, I'm not an expert  
4 on the regulation side but I think what's really important is that innovation isn't  
5 stifled. You see there are multiple different approaches being looked at, they  
6 are vastly different. And what is really important is they're not forced into a  
7 certain direction now because we're not sure which is the winner, we don't  
8 have a complete system.

9 And when you look at the hazards, it is important to say  
10 there are these hazards, these hazards can be mitigated and studies have  
11 shown that based on everything we've looked at to date. But coming clean  
12 with the hazards is important.

13 COMMISSIONER BARAN: And whether we're talking  
14 about a regulation, rulemaking, or whether it's guidance, one potential benefit  
15 of that is to have a more consistent framework across the country. And I'm  
16 interested in your thoughts a little bit about that.

17 The agreement states are already active in this area, they're  
18 more active than we've been in this area, but particularly in the absence of a  
19 fusion-specific framework, it could be that different agreement states will take  
20 different approaches and it may not be consistent across the country.

21 Is that something you all as developers are concerned  
22 about? And from the agreement state point of view, would that guidance or  
23 regulation at the appropriate time be helpful to establish that framework?

24 MS. SHOBER: At least from the agreement state

1 perspective, there really are very few states that are actively engaged in fusion  
2 right now. Obviously, the States of Massachusetts, Wisconsin, California,  
3 and New York. And that's really it for right now. I promise you, those states,  
4 we are talking to each other, we've had lots of conversations, sharing licenses,  
5 talking with license reviewers, that information is being exchanged.

6 Also, through the CRCPD, we have a taskforce for fusion  
7 issues that does include several different state participants and also NRC staff  
8 participation. There are forums already there to exchange that information  
9 and we're all looking for all the help that we can get. So, I don't foresee too  
10 much of a licensing in a vacuum, at least with these kinds of novel  
11 technologies in the short-term.

12 COMMISSIONER BARAN: That's helpful.

13 DR. MUMGAARD: I think it's important to recognize that  
14 we do have a mechanism already with the agreement states that enforces  
15 consistency with the national regulations. We saw this, where the review was  
16 a different agreement state to be aligned with the rulemaking. So, it's not like  
17 we're going to offshoot and not be able to get back on track. There's going  
18 to be a herding that's going to happen in the future, and that mechanism  
19 already exists.

20 From a developer's standpoint, the ability to engage locally  
21 is really important. At the end of the day, this is a local issue and so having  
22 the regulator on the site and seeing the stuff and talking to the neighbors is  
23 really, really important.

24 And the state agreement state model really facilitates that.



1 The other side of it is, from a developer's standpoint, we don't have certainty  
2 that that interaction is going to be exactly the same everywhere.

3                   It was never going to be exactly the same everywhere  
4 anyway. The neighbors are going to be different, it's going to be a continual  
5 engagement mechanism already. So, we're not so worried about the types  
6 of bumps and wiggles that might show up in this learning phase. We're also  
7 not building hundreds of these, these companies are looking to build their first  
8 one and then maybe their second and their third. Ten years from now we're  
9 going to know a whole lot more when we're at the stage of trying to build a big  
10 roll-out.

11                   MR. DESAI: One thing just to add quickly is right now we're  
12 figuring out our technologies. It would be a significant possible misuse of staff  
13 resources to try to write down every rule today. However, there will be a point  
14 in time where you can build a framework around the devices of the technology  
15 and I think we would actually appreciate that because it would build uniformity.

16                   However, there are some really cool options where you can  
17 apply lessons learned from prior Part 30 framework towards this approach. I  
18 would like to go back to Part 35. Part 35 actually has different subparts for  
19 different applications, so radioactive materials to medicine. It has that Part  
20 35-1000 process I mentioned before that brings in new technologies.

21                   You can imagine starting with guidance now, at some point  
22 building the bones of a Part 30-something for fusion, and you would start with  
23 basic requirements, build in a process for enabling innovation, technology to  
24 come in, and then building more subparts as you identify a concrete need

1 based on applied licenses for regulations around certain types of issues. And  
2 so there's a very organic way you can develop that, over a significant amount  
3 of time you have to get fusion on the grid.

4 COMMISSIONER BARAN: I probably could go another 40  
5 or 50 questions but I should stop now. I'll turn it over, thank you.

6 CHAIR HANSON: We all can. Commissioner Wright?

7 COMMISSIONER WRIGHT: Thank you and good  
8 morning. This is fascinating stuff, I'm actually more engaged in this since  
9 sitting here today, and I was already engaged. Holy cow. So, a lot has been  
10 happening recently. Yesterday, I think the response to the ACRS letter came  
11 out too so I am going to bring it up, maybe you can speak to it if you have  
12 anything you want to say to it.

13 To get started, and anybody can pitch in either online,  
14 virtually, or here in person, the ACRS did weigh in on the staff's white paper,  
15 on license and regulation of fusion energy and the systems, and one of the  
16 recommendations from the letter was that a hybrid byproduct materials and  
17 utilization facility framework be pursued, considering potential higher  
18 consequences of fusion energy facilities, whatever.

19 So, I look forward to hearing in the second panel what the  
20 staff might add onto that. But I might hear maybe your reactions to what  
21 came out and specifically how would the adoption of some hybrid approach  
22 impact you specifically and maybe, if not, do you have some concerns about  
23 it? Wherever you want to go.

24 MR. DESAI: Let me first start by saying that I appreciate

1 the strong work the ACRS has done towards ensuring nuclear safety. When  
2 I was a law clerk the first meeting I actually went to was an ACRS meeting, so  
3 I had the chance to understand how they work from the start and that's been  
4 very helpful.

5 I would say there's a couple of points I would raise. To  
6 echo off the bat before we get into the hybrid, the ACRS letter talked about  
7 past publications and issuances on fusion safety. I think we should recognize  
8 there are more recent issuances on fusion safety by DOE, the burning plasma  
9 report, which actually noted that Parts 20 and 30 are well suited to fusion  
10 technology, as well as the U.K. analysis, which complements years of work,  
11 and concluded that the fusion hazards are akin to more of a Part 30-type set  
12 of licensee.

13 But going to the hybrid framework approach, I think what the  
14 ACRS does point out is that in the future, as we're all getting to here, there  
15 may be fusion devices that have uncertainties we can't account for. But I  
16 think what we have to think about is does that mean that Part 30 can't be  
17 scaled to meet that need? I think we should look at is there anything in Part  
18 50 that actually provides some sort of tool that we can't add into Part 30 and  
19 provide a consistent single framework for fusion going forward, as opposed to  
20 having to choose between two frameworks.

21 There's actually a note in the paper that says that the issue  
22 with Part 30, they say that Part 30 can be scaled for fusion but the issue is it  
23 creates a patchwork of regulations, that's at least how I read it. And I don't  
24 think it creates a patchwork of regulations, I think that actually creates a path

1 forward. It's scaling Part 30 to eventually meet the need. And the biggest  
2 patchwork for us is not knowing which framework we're going to have at the  
3 start.

4 I think when I look at the fusion licensing, we don't need to  
5 get every word down at the start, we need to get the principal frameworks  
6 right. But I can't go to an investor and say that we could be in Part 30 or we  
7 could be in Part 50. Our regulatory offices, we don't even know where we're  
8 going to be. And so I think what ACRS points out is there are hazards, we  
9 absolutely need to keep counting and evolving that framework but there's  
10 nothing in the Part 30 that isn't capable of doing that. We've just got to spend  
11 time and attention to develop a proper paradigm for fusion within that  
12 framework over time and keep learning.

13 DR. MUMGAARD: I appreciate the ACRS weighing in on  
14 this, I also really appreciate the fact that the NRC really studied this for two  
15 years and the ACRS is a briefing and then a paper. And the NRC came up  
16 with options and ACRS said Option 3. What is Option 3? We're going to  
17 talk about it later but I'm going to try to summarize it somewhat quickly.

18 Option 3 is we'll draw a line through fusion machines and  
19 some of them will be utilization facilities and some will be Part 30 facilities.  
20 That's what it is. Does that give certainty? Let's analyze what the problems  
21 with such an approach would be.

22 I think there's four basic problems. One, we just talked  
23 about how the hazards of a fusion machine and the operating principles are  
24 like all of the other byproduct things. So, if you're going to draw a line through

1 fusion machines, you're going to have to draw the line through particle  
2 accelerators, too. Because these things are all really close. To say, oh, it's  
3 10 grams of tritium, well, there's lots of facilities that have 10 grams of tritium.  
4 So, there's a challenge, how do you draw that line fundamentally?

5           Additionally, the things you would use to draw that line  
6 almost have nothing to do with the actual hazard to the public. You draw a  
7 line on how much power a machine makes. You can make a machine that  
8 has lots of power that's unsafe, you can make a machine that has lots of power  
9 that's safe. It depends on barriers, engineering judgment, a lot of things that  
10 go into the discussion. It's not just about straight up inventory or how long the  
11 machine ran or how much power the machine made.

12           So, it's actually really difficult to draw that line. Then  
13 additionally, you would end up building today, two regulatory frameworks for  
14 fusion. You would take the utilization framework and adapt it somehow. I  
15 don't know how you would do that, I've not seen a really good proposal on  
16 how you would do that. And you would still have to do things in Part 30. So  
17 you would take the regulator and split them into making two sets of rules.  
18 That's a lot of effort that I don't think we can afford. That can actually impact  
19 public safety negatively by basically spreading our resources so thin.

20           And then fourth, really importantly, it doesn't provide any  
21 certainty, it doesn't meet NEIMA. It just leaves a big set of open questions of  
22 what's the line, who's doing what, where do you go, how do you know if you're  
23 above or below the line if you're doing an early design, what if you do the  
24 analysis and you end up on one side or the other. There's just a whole lot of

1 uncertainty that basically leads to I think the company is now probably looking  
2 elsewhere to places that have done the work upfront to say we have a certain  
3 scheme that is going to evolve over time.

4 COMMISSIONER WRIGHT: That's very good. Thank  
5 you very much for that. Does Mr. Lewis-Smith have any comment on this at  
6 all or anybody online?

7 MR. LEWIS-SMITH: Yes, please, I'll go for it, I know Seth  
8 has his hand up as well but if I could very briefly?

9 Just to echo what Sachin was saying, in the letter I noted  
10 that it said the NRC staff has not identified specific technical limitations  
11 associated with byproduct material framework that would preclude  
12 establishing requirements...et cetera. I think that actually is very similar to  
13 something we've been looking at in the U.K., which is the Health and Safety  
14 Executive is establishing a new consent authorization process within the  
15 existing framework.

16 In other words, there's no change to the law, no change to  
17 implementing regulations. However, they have introduced a new process  
18 that requires an operator of future fusion facilities, for example, to submit a  
19 safety assessment to the regulator. That will then come be inspected by  
20 specialists and then a consent would be granted. That's much more  
21 oversight than is now but that's nothing to do with the change of the  
22 regulations.

23 It's that kind of enhancement of evolution of the framework  
24 that can happen within existing regulations and I think that's just to illustrate

1 perhaps what Sachin was trying to allude to. It's very much certainly how  
2 we're doing things in the U.K.

3 MR. DESAI: Yes, I think that's right, we have the ability to  
4 scale the regulations over time to meet the need. I'll also just add I believe  
5 that the other members of the industry may provide responses as well to that  
6 ACRS letter over time.

7 COMMISSIONER WRIGHT: And Mr. Lewis-Smith, I'm  
8 going to stay with you for a second here, you're leading fusion regulator and  
9 you've really looked at pros and cons and different regulatory frameworks for  
10 fusion. I'd be interested to hear if you have any suggestions or tips that you  
11 might have for the NRC as we go about considering these different regulatory  
12 approaches?

13 MR. LEWIS-SMITH: Thank you. The one thing I would  
14 say, I don't want to make too much of comparing the U.S. and the U.K.  
15 approaches, we do things very different in terms of our legal apparatus but  
16 one of the things I said earlier about the goal-setting approach, the  
17 requirement for that fusion developers to explain to the regulators how they  
18 assess the risk and mitigated them as far as reasonably practical.

19 We think that kind of fundamental approach is really  
20 beneficial. How that is then implemented at state or federal level or through  
21 which regulation is less of an issue. It's the fundamental of how the  
22 framework works, which for us is really important. But otherwise, I think  
23 everything we've heard from the panel today and I hope things that I  
24 mentioned in my presentation about trying to define those bounding scenarios,

1 enabling flexibility and acknowledging there are uncertainties. If you can  
2 arrive at a conclusion that has done all that then we think you will have been  
3 on the same journey as we've done.

4 COMMISSIONER WRIGHT: And with the time I've got left,  
5 Mr. Chairman, I want to talk to Ms. Shober for a second. First, I'm very happy  
6 that you're here, I'm very grateful for your comments, too. At the CRCPD  
7 meeting that we had earlier this year, you were on a panel with Duncan White  
8 and I believe Jeff Semanchik from Connecticut, I think. And you all talked  
9 about this and what the states were trying to do. I've been very impressed  
10 with what I heard then and especially what I heard today.

11 I kind of wish you all were the second panel because I would  
12 like to, based on what you've heard today so far from the panelists here, I just  
13 wondered if there's anything you'd like to add or something you think we need  
14 to further look into or consider as we go through this, even though you don't  
15 know what the next panel is going to say. It would be interested in that  
16 because the whole agreement states program is an amazing program working  
17 with the NRC and I see you all, it looks like you're going to be huge players on  
18 this.

19 MS. SHOBER: Thank you for your comments. I think  
20 what I'll toss in here is I think that the agreement states at this point have more  
21 fusion regulatory experience than the NRC and that puts us in a bit of an  
22 awkward position because you guys are the ones that are making the  
23 decisions about what framework we're going to end up with.

24 But on the research front, the people that have come to us



1 that are applying for fusion licenses at this point, they aren't coming in with a  
2 fully formed giant facility project. So, we've had the luxury of starting small  
3 on things that grow over time. I know that what CFS is doing is a little bit  
4 different on the time-scale but we've had years to run into these obstacles to  
5 figure out how to climb over them to figure out how to streamline things to  
6 identify those challenges.

7                   And so I guess one of the things that's hard for me as I'm  
8 listening to this about the hybrid approach is we could very easily end up in a  
9 situation where all of the R&D pieces happen with agreement states. We  
10 have this many-year relationship with our licensees, we understand how they  
11 operate, we understand their systems, and all of the sudden they cross a line  
12 and now they're a utilization facility and they're regulated by the NRC.

13                   And so I think in that case, that's a challenge for you as a  
14 utilization facility regulator because you don't have that knowledge that's built  
15 up with all these years of working with an applicant. And then it's also very  
16 hard for the fusion companies because now all the training they've given us,  
17 all the many conversations and years back and forth, they would basically be  
18 starting over with a different set of regulators. And I think that duplicating that  
19 effort and all that, there are consequences for that as well. And so I understand  
20 the position that you're in considering these issues and trying to figure out  
21 where to draw the line or should you draw the line.

22                   I'm glad I'm not the one doing that. From an agreement  
23 state perspective, we understand the licensees that we've been working with  
24 and we are developing the capabilities like everyone else in the country to

1 regulate more complex and larger and different, evolving systems.

2 MR. DESAI: Actually, you reminded me of something I  
3 wanted to raise which is with regulations we can change and modify  
4 regulations over time so you can take one framework and build it up. The  
5 harshness of that Part 30-Part 50 switch is actually, you're also changing the  
6 statutory requirements. You're moving fundamentally from one regime that  
7 has a set of very flexible statutory requirements to a regime that has a  
8 completely different set of statutory requirements, and that would be  
9 something that would be nearly, almost impossible to make that transition.

10 The beautiful part about scaling up the Part 30 framework,  
11 for example, or building a custom framework within the materials approach is  
12 that you have the same set of flexible statutory requirements you can apply to  
13 fusion licensees and applicants, but you still at the end of the day have the  
14 same adequate protection standard.

15 So, you meet the same federal standard but you have a set  
16 of statutory requirements in place that's consistent over decades and allow for  
17 the Agency and states to have the most flexibility on the path they want to  
18 pursue.

19 DR. MUMGAARD: I'll just put in the point of SPARC relief.  
20 If we had done TFTR under the hybrid approach, what it would have meant is  
21 we ran TFTR for 10 years under one regulator and then one day the same  
22 exact facility, we decided to run it under a different regulator. And then the  
23 next day we went back. That's because these facilities evolve over time, you  
24 can put different fuels in them, you can run them with higher power or lower

1 power, it's part of the innovative cycle to be able to do that. And that's much  
2 better done by a team of local experts that have been there for a while than  
3 by throwing it over the fence.

4 CHAIR HANSON: Thank you. Commissioner Caputo?

5 COMMISSIONER CAPUTO: The difficult thing about  
6 going last in questions is so many of the good questions have already been  
7 asked, so maybe I will end up being a little more concise and not using my full  
8 time.

9 I do want to try and create a little bit of clarity around a lot of  
10 the discussion that we've heard better using Part 30. Let me just start with  
11 Mr. Desai and Dr. Mumgaard. It sounds like for the nature of what you're  
12 planning to do in your companies, you really need regulatory certainty within  
13 the next two years or perhaps less. And you clearly stated your comfort with  
14 Part 30, perhaps with some modifications through guidance.

15 Dr. Hawryluk, given the other technologies out there, and  
16 maybe Dr. McCarthy as well, the universe of technologies that we know about  
17 now, is it your sense that those would probably fit under Part 30 as we have it  
18 today but perhaps with some guidance modifications?

19 DR. HAWRYLUK: I think for the near-term experiments  
20 that people are working on, I'll give an example as SPARC that we talked  
21 about and others which are in the pipeline right now, I think Part 30 will work  
22 just fine. There are some questions that need to be addressed as to what  
23 additions and modifications to Part 30 are needed for the future pilot plan.  
24 And we're in the process, some groups hope to do it faster than others to get

1 to a preliminary design to define this. By the time they're at the preliminary  
2 design, they have to have some fairly concrete assurance as to what the  
3 regulatory framework will be and what the expectations are.

4 So, each machine, each concept is probably slightly  
5 different on the time scale but I think we're talking about several years, but  
6 there are some near-term things that Part 30 will work on. Downstream you  
7 probably need to modify that, in some cases it's a perhaps, I think it's a  
8 perhaps, to address some of the issues that the ACRS raised.

9 COMMISSIONER CAPUTO: I'll just stay with you for a  
10 minute. What I want to try and get a better understanding of is what's the  
11 time horizon here for some facility that's envisioned that needs to come in with  
12 a regulatory framework that somehow warrants regulation outside Part 30 or  
13 a significantly different Part 30 that would warrant us going through a  
14 rulemaking process?

15 Because I think certainly, in my experience, no matter how  
16 narrow of a modification to our rules is, the rulemaking process itself is quite  
17 time-intensive. So, we talked about if it's a hybrid approach, what kind of a  
18 threshold would warrant something more significant? Can you, given your  
19 attempt to find a milestone schedule for fusion development, give us an idea  
20 of when you see a potential device that might need to go beyond Part 30 with  
21 some modifications and into rulemaking space?

22 DR. HAWRYLUK: Going back to the NASEM study, we  
23 were talking about the preliminary design for these fusion pilot plants in about  
24 five years, which is about four years from now if you look at when we issued

1 that report. And so at that stage, it would really behoove us to have the  
2 regulatory framework fairly well-defined. At that point, switching from a  
3 byproduct utilization facility, I can imagine and people here, Bob and Sachin  
4 should really comment on this further, we would find it very disruptive. So, I  
5 think that's talking about the fusion pilot plant, it's not talking about near-term  
6 facilities such as SPARC.

7 DR. MUMGAARD: I'm happy to provide a timeline of how  
8 we think about the problem. We're building a machine right now and that  
9 machine is under existing rules. That machine, you turn it on in 2025, operate  
10 it, at that time I'll need to have a materials license, that process is underway.

11 Then you think about a pilot plant, a pilot plant is what the  
12 NASEM report recommended, it's what the decadal plan is aiming at. There's  
13 an FOA to get money out from DOE to actually build such pilot plants to  
14 multiple award winners.

15 Those plants, that timeline, basically are all let's have a  
16 conceptual design of that pilot plant in about 18 months. So, at that point you  
17 know what that thing looks like, you know its size, you know its power output.  
18 It's a pilot plant, this is not an experiment, this is a machine that's designed to  
19 get through environmental cycles, it's designed to show some commercial  
20 implications. It's not just prove a principle.

21 So that means in 18 months we probably need to know  
22 where we're headed on these regulations. When do you actually start  
23 construction on such a plant? By the time you start construction, you have to  
24 know what the rules are, otherwise you don't start.

1                   The Loan Program Office doesn't get you a loan, DOE  
2 doesn't get you past CD whatever, and investors don't give you the money to  
3 do it. So, you have to know before you start construction.

4                   Various companies here are looking at starting construction  
5 in the next three to four years of such a thing and if you look at the bounding  
6 of the NES report, it's not more than five years, six years away from what the  
7 decadal plan says. That gives you a sense of when that window is. We think  
8 those pilot plants could be within Part 30 with some modifications and  
9 definitions. but we'd have to know what that looks like at that time.

10                  MR. DESAI: Just to highlight, we're planning to start  
11 construction on our first commercial facility in the near term in a similar time  
12 scale, which means we actually have to start pre-application engagement with  
13 the appropriate regulator next year, essentially. So, we're looking at it to  
14 understand the framework in the very near term.

15                  If I may make a strawman suggestion, taking some of the  
16 feedback from this conversation, it sounds like there will be a couple  
17 applicants coming in in the next year or earlier to start pre-application  
18 engagement. Those applications will be the test case for fusion and we can  
19 do that and I think it's actually broader than that, we can do that under the Part  
20 30 framework with guidance or limited rulemaking based on what the states  
21 and the NRC staff think is the most appropriate.

22                  At that point, that's going to be the threshold, when you have  
23 initial experience with a couple license applications to start building a  
24 framework for fusion. You also have proven that fusion works so there will

1 be a lot more attention on this from funding and availability to develop a proper  
2 framework.

3 I'll note that 10 CFR Part 38 is an empty part of the  
4 regulatory code and so may or may not be a good place to start getting the  
5 bones of a fusion framework. And again, I'll take the 35 analogy, you have  
6 basic rules in place and you build subparts and you build in a process to intake  
7 new technologies as it comes along. And so I can see that as being a multi-  
8 step process that proceeds with the technology to build a framework that can  
9 scale for fusion.

10 COMMISSIONER CAPUTO: I'm going to ask a slightly  
11 different question. Getting into liability and insurance, fission reactors have  
12 to join the Price Anderson framework under law because the liability of a  
13 nuclear accident exceeds the value of insurance that's commercially available.

14 So, I'd like to ask the both of you do you see yourselves  
15 needing access to that framework or do you see the liability resulting from a  
16 possible accident scenario being bounded by the insurance that you find  
17 commercially available on the market?

18 DR. MUMGAARD: It's a great question.

19 I think a lot of the studies that have been done in the U.K.  
20 and elsewhere have shown that the bounding scenarios here for an accident  
21 are not what we think about in fission because you don't have uranium, you  
22 don't have chain reactions, you don't have transuranics. It's just a different  
23 reaction altogether. And it actually shows up in the insurance markets, so  
24 SPARC is an insured facility that's on the commercial market. I believe even

1 ITER is on the commercial market for insurance.

2                   And so that says that we don't think Price Anderson makes  
3 a lot of sense to apply across those technologies, they're too different. In  
4 effect, what you would be doing is one technology would be subsidizing  
5 another technology when, at the end of the day, they're actually completely  
6 opposite reactions.

7                   MR. DESAI: I can say we do not anticipate, nor do we want  
8 to be under the Price Anderson framework. We believe and we are confident  
9 we can develop an insurance market for fusion devices. It's actually a project  
10 I've undertaken working with an insurance broker to go and introduce fusion  
11 to a number of insurance companies.

12                   Actually, and also, this was at the International Nuclear Law  
13 Association conference a couple weeks back, where I posed this question to  
14 nuclear insurers about what do you think about fusion devices needing  
15 insurance. And a number of them came back to me and said I don't see any  
16 need for a Price Anderson or a particular government regime to apply fusion  
17 commercial markets can cover you.

18                   I think one thing we should recognize is the commercial  
19 market in the 1950s and 1960s for insurance was a lot different than the  
20 commercial market today. And fundamentally, because we're pursuing a  
21 particle and cellular approach in which the inventory hazard within the device  
22 is quite limited compared to the external materials hazards, there's a lot of  
23 experience dealing with that type of set of hazards in the commercial  
24 insurance space.



1                   COMMISSIONER CAPUTO: Thank you for your  
2 participation and contributions today. Clearly, this is a very vibrant  
3 discussion, it's an exciting time, a nascent industry for fusion, which I find  
4 absolutely fascinating. So, thank you all for your contributions today and  
5 that's it for my questions.

6                   CHAIR HANSON: Thank you, Commissioner Caputo.  
7 Let me echo her comments, thanks again to all of our panelists this morning  
8 and also, particularly to our remote participants, Mr. Lewis-Smith from the U.K.  
9 and Dr. Hoedl. It was a pleasure to have you with us and with that we'll take  
10 a short break. We'll reconvene probably just at 11:02 a.m., 11:03 a.m. so we  
11 can get started with the NRC staff panel. Thank you all again.

12                   (Whereupon, the above-entitled matter went off the record  
13 at 10:57 a.m. and resumed at 11:04 a.m.)

14                   Welcome back, everybody, let's get rolling here on the  
15 second panel. This second panel is the NRC staff panel and it will be kicked  
16 off by Cathy Haney, the Deputy Executive Director for Materials, Waste,  
17 Research, State Tribal Compliance, Administration, and Human Capital  
18 Programs. Cathy?

19                   MS. HANEY: Good morning, Chair Hanson, and  
20 Commissioners. It's a pleasure to provide an update on the NRC Staff's  
21 efforts to develop options for licensing and regulating fusion energy systems.

22                   Consistent with national energy priorities, the Administration  
23 has stressed the importance of creating a regulatory environment that  
24 supports continued research and development and progress towards

1 commercialization of fusion energy.

2                   Additionally, the Nuclear Energy Innovation and  
3 Modernization Act, or NEIMA, requires the NRC to develop a regulatory  
4 framework for fusion reactors, which the NRC staff refers to as fusion energy  
5 systems.

6                   While the NRC has a mature regulatory framework for  
7 fission reactors, its regulations do not explicitly address fusion energy  
8 systems. Developing an appropriate regulatory framework that meets the  
9 NRC's safety and security mission is essential for providing regulatory clarity  
10 and predictability to an advancing fusion industry.

11                   As directed by the Commission, the NRC staff is developing  
12 options for regulating fusion technologies while enabling research and  
13 development in the eventual safe commercial deployment of fusion energy.  
14 To that end, the NRC staff established a fusion energy system working group  
15 consisting of a diverse array of agency staff. Two members from the  
16 Organization of Agreement States were included in the working group to  
17 provide insight into the states' current experience with licensing and regulating  
18 fusion activities.

19                   The working group's insights are reflected in the NRC staff's  
20 September 2022 white paper, which the staff issued to inform discussions with  
21 the Advisory Committee on Reactor Safeguards and to gather feedback on  
22 potential regulatory approaches for fusion energy systems. Based on  
23 feedback received on the white paper, the NRC staff continues to refine these  
24 options and our supporting rationale.

1                   For example, the NRC staff is developing a detailed analysis  
2 of whether and when a fusion energy device should be considered a utilization  
3 facility as defined in the Atomic Energy Act, and is assessing past mission  
4 decisions where non-reactor technologies were determined to be utilization  
5 facilities.

6                   The NRC staff is also evaluating whether any legislative  
7 changes or additional statutory authority are needed or desirable to facilitate  
8 an appropriate regulatory framework for fusion energy systems. This thinking  
9 and other changes that address the valuable feedback from the Advisory  
10 Committee on Reactor Safeguards will be incorporated into a notation vote  
11 paper that the NRC staff will provide for the Commission's consideration by  
12 the end of this year. Next slide, please.

13                   On this panel, you will hear from Andrea Veil, who will  
14 discuss the NRC's development of a regulatory framework for fusion energy  
15 systems, Duncan White, who will give an overview of fusion technologies  
16 under consideration, and they're associated risks and hazards. Andrew  
17 Proffitt, who will discuss the options developed by the NRC staff for licensing  
18 and regulating fusion energy systems, and finally, Dr. Joseph Staudenmeier  
19 will provide an overview of the NRC staff fusion research activities and our  
20 efforts to ensure the NRC's continued readiness to efficiently license and  
21 regulate fusion energy systems.

22                   I'll now turn the presentation over to Andrea.

23                   MS. VEIL: Thank you, Cathy, good morning, Chair and  
24 Commissioners. The NRC's principles of good regulation including

1 independence, openness, efficiency, clarity, and reliability anchor us in  
2 accomplishing our safety and security mission. These principles have guided  
3 our decision-making and helped us to adapt to evolving landscapes for fusion  
4 technology.

5                   This morning I'll discuss how we incorporate Commission  
6 and Congressional direction and leverage insights from the current regulatory  
7 treatment of fusion research and development activities. These insights  
8 reflect both domestic and international perspectives and assisted the NRC  
9 staff in developing actions for licensing and regulating fusion energy systems.  
10 Next slide, please.

11                   The NRC staff is currently preparing a recommendation for  
12 a regulatory framework to support commercialization of fusion energy  
13 systems. In 2009, the Commission asserted regulatory jurisdiction over  
14 commercial fusion energy systems whenever such devices are significant to  
15 the common defense and security or could affect the health and safety of the  
16 public. However, they directed the NRC staff to wait until commercial  
17 deployment of fusion technology became more predictable before expending  
18 significant resources on developing a regulatory framework.

19                   In 2019, NEIMA directed the NRC to complete a rulemaking  
20 to establish a technology-inclusive regulatory framework for advanced  
21 reactors including fission reactors no later than December 2027. For  
22 advanced fission reactors the NRC staff is well on its way to developing this  
23 framework with the 10 CFR Part 50 rulemaking. We remain on track to  
24 provide the draft framework and proposed rulemaking package for the

1 Commission consideration by February 2023 and to issue the final rule by mid-  
2 2025.

3 Consistent with the Commission's direction on the Part 53  
4 rulemaking plan, the NRC staff is developing options for fusion regulation as  
5 a separate effort to ensure predictability and reliability. Our progress is  
6 consistent with the maturity and readiness of the technologies. Following a  
7 Commission decision on the notation vote paper on fusion and consistent with  
8 NEIMA, the NRC staff plans to develop the regulatory framework for fusion for  
9 near-term fusion energy systems by the end of 2027. Next slide, please.

10 To date, fusion research and development in the U.S. has  
11 largely been carried out under the purview of the Department of Energy.  
12 Additional research and development has been performed under the  
13 jurisdiction of the agreement states using authority assumed through their  
14 agreement with the NRC or their general authority.

15 The NRC staff has been engaging DOE to understand the  
16 operating characteristics and treatment of fusion energy systems under their  
17 purview. The NRC staff is also learning from DOE's international activities  
18 including its collaboration with 35 countries on the international thermonuclear  
19 experimental reactor, or ITER, located in France. ITER, which is pictured on  
20 the left, will be the world's largest fusion experiment when completed.

21 The NRC staff also closely coordinates with the agreement  
22 states to gain valuable insights based on their experience regulating private  
23 and academic fusion research and development facilities under programs  
24 compatible with the NRC's regulation for byproduct materials.

1                    Pictured on the right is Commonwealth Fusion System's  
2 SPARC facility that is currently under construction in the Commonwealth of  
3 Massachusetts. Both ITER and SPARC are Tokamak designs; however,  
4 SPARC and the planned commercial version, ARC, are significantly smaller  
5 in size than ITER.

6                    Additionally, the fusion energy systems working group that  
7 Cathy mentioned engages in extensive discussions with the broad spectrum  
8 of stakeholders, including technology developers, national labs, and industry  
9 groups. The working group also cooperates with a wide variety of  
10 international regulatory partners to share technical and legal insights, good  
11 practices and lessons learned for mutual benefit and experience. Andrew will  
12 discuss our stakeholder engagement in much more detail.

13                    Consistent with the NRC's approach to evaluating safety for  
14 advanced fission technologies is essential to appropriately consider the  
15 significance of fusion technologies to public health and safety and common  
16 defense and security, and to apply an appropriate regulatory framework  
17 commensurate with the significance of the risk and their hazards.

18                    Fusion technologies could be safely regulated through a  
19 utilization facility licensing framework, byproduct materials framework, or  
20 hybrid approach of the two depending on the significance of the risk and  
21 hazards posed by the particular design.

22                    Throughout our outreach efforts the NRC staff has learned  
23 that designs and technologies have evolved substantially from the concepts  
24 considered just a few decades ago. The NRC staff believes that near-term

1 designs based on their operating characteristics, anticipated material  
2 possession, and associated radiological hazards could be appropriately  
3 regulated under a byproduct material framework. However, as the fusion  
4 energy industry further matures, designers may develop fusion energy  
5 systems that have new or greater hazards than near-term concepts and may  
6 be more appropriately regulated as utilization facilities.

7 Thank you and I will now turn the presentation over to  
8 Duncan White, who will provide more detail on the technologies, risk, and  
9 hazards of fusion energy systems and get some water.

10 MR. WHITE: Thank you, Andrea. Good morning, Chair  
11 and Commissioners. This morning I'll provide an overview of the diverse  
12 near-term fusion energy system concepts discussed and associated hazards,  
13 which differ from operating fission power reactors, and the potential for using  
14 NRC's byproduct material framework as the foundation for the regulation.

15 The NRC's byproduct material framework is well suited to  
16 address the hazards at proposed fusion facilities based on the expected  
17 operating characteristics, material possession, and accident sequences at  
18 these facilities. Next slide.

19 As you heard in the first panel, the fusion industry believes  
20 recent technological breakthroughs will enable demonstration of the feasibility  
21 of fusion energy in the mid-2020s and support deployment of commercial  
22 fusion energy systems in the 2030s. While there is no generic fusion  
23 power-plant, the NRC Staff has a practical understanding of the major fusion  
24 technologies, including most near-term concepts and variations across

1 different developers.

2                   The NRC considers both commercial and research and  
3 development fusion energy systems that are currently contemplated for near-  
4 term deployment during the development of options for a regulatory  
5 framework.

6                   While fission splits heavy elements such as uranium-235  
7 into two smaller elements releasing energy and neutrons, fusion combines two  
8 low atomic number elements or particles releasing energy along with charged  
9 particles and neutrons. Fusion energy systems can produce tritium,  
10 neutrons, and neutron activation products that need to be properly contained  
11 to protect public health and safety. There are several different technologies  
12 being commercially pursued for fusion energy systems. These technologies  
13 can be grouped into three general plasma confinement approaches, magnetic,  
14 inertial, and magneto-inertial confinement. These methods generally seek to  
15 create an environment with adequate density, temperature, and energy  
16 confinement, time to enable sufficient fusion reactions to produce a net energy  
17 gain.

18                   Most designs used the deuterium-tritium, or DT, reaction  
19 because it has historically been seen as the easiest path to an energy  
20 production breakeven point. However, some fusion technologies may use  
21 aneutronic fuels such as proton, boron-11, or deuterium-helium-3. While  
22 aneutronic fuels do not produce neutrons as part of their reaction, they do  
23 produce radiation including neutrons produced in secondary reactions.  
24 Therefore, commercial devices are expected to require shielding and barriers



1 to radiological releases to protect public health and safety.

2                   With magnetic confinement, a high temperature, light  
3 nuclear fuel plasma is contained by a strong magnetic field using  
4 superconducting magnets within a vacuum vessel. They operate in a steady-  
5 state mode with only a fraction of the size of the tritium inventory present in  
6 the plasma within the vacuum vessel at any one time. A large portion of the  
7 tritium inventory will typically be in the tritium handling system where the tritium  
8 is recovered, processed for injection, and stored.

9                   The Tokamak magnetic fusion approach has historically  
10 been the focus of most research and development within the fusion energy  
11 community and has been the most studied. With inertial confinement, a  
12 capsule of light nuclear fuel is compressed by laser beams or other means  
13 within a chamber to increase the density and heat the material.

14                   Although the general conditions for releasing energy from  
15 the fusion energy system are essentially the same for inertial confinement as  
16 for magnetic confinement, inertial designs require higher plasma densities  
17 than magnetic designs because the energy confinement time is much shorter.

18                   Finally, the magneto-inertial confinement designs involve  
19 some combination of magnetic and inertial approaches. Generally, these  
20 designs use magnetic fuel to combine and initial plasma that is then  
21 compressed and heated directly to fusion conditions.

22                   Both inertial confinement and magneto initial confinement  
23 designs are pulse-powered designs that seek to achieve energy gain on each  
24 pulse. Given the diversity of designs, a technology-inclusive,

1 performance-based approach to fusion energy system licensing and  
2 regulation is critical. Next slide, please.

3                   Understanding the hazards associated with proposed fusion  
4 energy systems is a key component in applying the appropriate regulatory  
5 framework that is commensurate with the risk they pose to public health and  
6 safety. Although several concepts have been around for decades, near-term  
7 designs have evolved and so has our understanding of the risks.

8                   The designs being pursued for commercialization are  
9 smaller than the large Tokamak concepts that had been the focus of  
10 international government back fusion programs such as ITER.

11                   While many studies of fusion technologies over the decades  
12 have evaluated the potential risks of these larger historical designs, the NRC  
13 staff has been careful to focus its attention on the current state of the  
14 technology.

15                   There have been advances in plasma physics,  
16 superconducting magnets, high-powered lasers, and computer capability.  
17 These advances have and are expected to continue to enable the design and  
18 operation of fusion energy systems with less fuel and with better control of the  
19 plasma as compared to historically studied systems.

20                   Changing inventories, particularly active inventory in the  
21 fusion device, are expected to be smaller. For example, historical designs  
22 are expected to have an active tritium inventory of approximately 1 kilogram,  
23 while near-term commercial designs are expected to have active inventories  
24 of less than 100 grams.

1           The quantities of activation products in near-term  
2 commercial designs are also being addressed to the development of structural  
3 materials with lower neutron cross-sections; therefore, while historical  
4 references are important to consider, near-term concepts are expected to be  
5 of lower radiological risk based on different designs, structural materials, and  
6 inventories of radioactive materials.

7           The most significant radiological hazards are driven by the  
8 inventories of reactor materials at the site, radiation produced during the  
9 operation and thus produced in the vacuum vessel. This includes tritium and  
10 neutrons from fusion reactions, activated components including dust, and  
11 gamma emissions. Confinement of these materials and shielding of the  
12 radiation are key areas of focus for protecting workers and the public.

13           The characteristics of the tritium produced or held on-site  
14 are important for radiation safety purposes. Tritiated water, gas, and dust  
15 particles can be present, contribute to the source term for potential offsite  
16 exposures, and must be tracked and monitored. Tritiated water and gas can  
17 be readily absorbed into the body and components, including metals.  
18 Components activated by neutron bombardment must be managed  
19 appropriately. Activation products and facility components will depend on the  
20 specific materials being used.

21           The quantities of activation products will build over time,  
22 which will increase the reactor material inventory. Dust which may contain  
23 tritium and activation products and be chemically reactive is generated in the  
24 vacuum vessel by energetic plasma surface interactions.

1                   Like activation products, dust will build up over time. These  
2 activated components and dust can have implications for certain accident  
3 progressions, waste disposal, and decommissioning, and will influence  
4 financial assurance requirements.

5                   Fusion energy systems also have non-radiological hazards  
6 which are design independent. The NRC staff will evaluate these hazards  
7 and their ability to impact radiation safety during routine operations and  
8 accident scenarios. Some non-radiological hazards including high magnetic  
9 fields, thermal shock from plasma disruption, loss of vacuum, hydrogen and  
10 dust explosions, chemical hazards, cryogenic releases, and high-powered  
11 lasers. The NRC staff will coordinate with other federal and state regulatory  
12 agencies to ensure oversight of these hazards. Next slide, please.

13                   As discussed on the previous slide, the radiological hazards  
14 associated with near-term fusion energy systems are expected to be driven  
15 by the possession and use of byproduct materials such as tritium. As such,  
16 the NRC staff is considering the potential for NRC's byproduct material  
17 framework to serve as the foundation for regulating fusion energy systems.  
18 This framework is currently used to safely regulate fusion research and  
19 development and some commercial activities.

20                   Materials made radioactive by particle accelerators is  
21 considered byproduct material if it is used for commercial, medical, or  
22 research purposes. Fusion devices operate in a similar manner to particle  
23 accelerators, as they create conditions conducive to fusion reactions by  
24 accelerating charged particles through electromagnetic interactions in a

1 vacuum and discharge the resulting particle and other radiation into a medium.  
2 These characteristics are consistent with the regulatory definition of particle  
3 accelerators and therefore, the reactor material produced by fusion devices  
4 could be considered byproduct material.

5           Additionally, the NRC's byproduct material framework is  
6 suitable for licensing and regulation of fusion energy systems from a technical  
7 standpoint. It is scalable, technology-neutral, and capable of addressing a  
8 broad array of fusion energy systems and their hazards.

9           The NRC's byproduct material framework includes  
10 high-level licensing that address design, safety, and security considerations  
11 relevant to fusion energy systems including emergency planning, financial  
12 assurance, decommissioning, physical security, training, facility design,  
13 radiation safety, and environmental protection.

14           Many features of the proposed fusion energy systems have  
15 been successfully regulated under NRC's byproduct material framework or are  
16 analogous to devices or a facility regulated by the NRC in agreement states  
17 using a byproduct material approach. Several planned fusion devices will  
18 use or produce tritium which the NRC and the agreement states have a long  
19 history of regulating, including large quantities as byproduct material.  
20 Devices that produce neutrons using the DT reaction for neutron generators,  
21 explosive detection, and well logging have been regulated under NRC's  
22 byproduct framework for decades.

23           It's important to note that while the NRC's byproduct  
24 material framework is protective of workers and the public for a wide range of

1 uses of reactor materials, it may not be appropriate for the commercial fusion  
2 energy systems with different risk profiles or higher hazards than the proposed  
3 near-term concepts.

4 Separately, most designs which use aneutronic fuel may  
5 only generate reactor materials incident to their operation and may not meet  
6 the current definition of byproduct material. Without amending the Atomic  
7 Energy Act, the radiological hazards and fusion concepts using aneutronic fuel  
8 would fall outside of NRC's jurisdiction and reside with the states.

9 I will now turn the presentation over to Andrew to give an  
10 overview of the options for licensing and regulating fusion energy systems  
11 developed by the NRC staff.

12 MR. PROFFITT: Thank you, Duncan, and good morning,  
13 Chair and Commissioners. This morning I'll provide an overview of our  
14 stakeholder engagement on this topic, discuss options for licensing and  
15 regulating fusion energy systems, and detail how the NRC staff is evaluating  
16 these options to make a recommendation for the Commission's consideration.

17 As Andrea mentioned, the NRC staff has determined that  
18 fusion technologies can be safely under a utilization facility framework,  
19 byproduct material framework, or a hybrid approach leveraging both  
20 frameworks. Next slide, please.

21 The NRC staff has proactively engaged stakeholders over  
22 the last 18 months to inform the development of these options. Through our  
23 engagements, the NRC staff sought to better understand the state of fusion  
24 energy technologies, projected pathways and schedules for

1 commercialization, and the potential risks and hazards associated with these  
2 systems. We also solicited stakeholder perspectives on the appropriate  
3 regulatory framework for the NRC to employ.

4           Some examples of this extensive outreach include six NRC-  
5 staff-led public meetings; a joint public workshop sponsored by the NRC, the  
6 Department of Energy and the Fusion Industry Association; the NRC staff  
7 participation in the White House Summit on developing a bold decadal vision  
8 for commercial fusion energy and the follow-on DOE workshop; international  
9 engagement through bilateral interactions and IEA activities. We coordinated  
10 with the organization of agreement states and, as mentioned, included  
11 agreement state representatives on the NRC's fusion energy system's  
12 working group.

13           We also held technology introduction meetings with private  
14 companies seeking to commercialize fusion energy and conducted three  
15 briefings on the Advisory Committee on Reactor Safeguards. Next slide,  
16 please.

17           Informed by stakeholder feedback, the NRC staff has  
18 developed three options for licensing and regulating fusion energy systems  
19 that are consistent with Commission and Congressional direction.

20           These options include a utilization facility approach, a  
21 byproduct material approach, and a hybrid approach that would introduce the  
22 decision criteria based on the potential risks and hazards to determine  
23 whether a specific concept should be licensed and regulated under a  
24 byproduct material or utilization facility regulatory framework.

1           The first option would treat all fusion energy systems as  
2 utilization facilities. To do this, the NRC staff would initiate a rulemaking to  
3 develop a single new regulatory framework to specifically address the hazards  
4 and risks posed by fusion energy systems, separate from NRC's current  
5 utilization facility frameworks.

6           As part of evaluating this option, the NRC staff is assessing  
7 whether currently contemplated fusion devices meet the definition of utilization  
8 facility in the Atomic Energy Act by making use of atomic energy in such  
9 quantity as to be of significance of the common defense and security or in  
10 such a manner as to affect the health and safety of the public.

11           The NRC staff's current analysis of near-term fusion energy  
12 systems indicates that these systems are unlikely to meet the common  
13 defense and security criterion of the Atomic Energy Act definition of utilization  
14 facility. The NRC staff's analysis is based on our consideration of the  
15 potential for radiological sabotage, need for material control, or risk of  
16 proliferation. For example, near-term designs do not use, possess, or  
17 produce special nuclear material, nor can they be readily adapted to do so.

18           Additionally, tritium and fusion device sales and exports are  
19 not currently subject to domestic and international safeguards programs and  
20 do not currently appear on the trigger list associated with the Treaty on the  
21 Non-proliferation of Nuclear Weapons.

22           The NRC staff's analysis of near-term fusion energy  
23 systems also indicates that these systems are unlikely to meet the public  
24 health and safety criteria of the Atomic Energy Act definition of utilization



1 facility.

2                   The NRC evaluates potential impacts to public health and  
3 safety by assessing operational risk and accident risk. Radiological risk from  
4 operations is controlled for all NRC license activities through compliance with  
5 10 CFR Part 20 and isn't a salient factor in determining if a fusion device is a  
6 utilization facility.

7                   The NRC staff's analysis of accident risk and non-  
8 radiological operational risk is based on consideration of operating  
9 characteristics, potential offsite consequences, and the contribution of the  
10 device to the radiological consequences of potential releases.

11                   As part of its analysis of near-term fusion energy systems,  
12 the following device characteristics were considered holistically to support the  
13 NRC staff's conclusions that these systems are unlikely to meet the public  
14 health and safety criterion of the Atomic Energy Act definition of utilization  
15 facility. Fusion devices will not use fissionable material and thus cannot  
16 achieve nuclear criticality, a self-sustaining chain reaction that requires  
17 positive means to stop.

18                   Fusion devices are expected to immediately cease energy  
19 and radioactive material production during an accident scenario. Only the  
20 material and energy present at the initiation of the event are available to  
21 contribute to a potential release. As such, implementation of extensive safety  
22 systems to prevent significant continued production of energy and radiological  
23 material in accident scenarios is not necessary.

24                   In the case of a total loss of active cooling, low residual

1 heating precludes melting of the device's structures in a potential release and  
2 offsite consequences during credible accident scenarios involving the fusion  
3 device are expected to result in low doses to the public without the need for  
4 extensive controls on the device.

5           Given the lack of common defense and security  
6 considerations, the low potential offsite consequences, and the lack of  
7 significant contribution of the device to the radiological consequences of  
8 potential releases, fusion devices need not be broadly classified as utilization  
9 facilities.

10           However, given the flexibility of the statutory language in the  
11 Atomic Energy Act, the Commission could decide to classify fusion energy  
12 systems as utilization facilities based upon its own consideration of the  
13 statutory criteria.

14           To implement such a decision, new provisions would need  
15 to be developed to ensure appropriate prevention and mitigation of  
16 radiological releases, recognizing that fusion technologies do not pose the  
17 same types of hazards as fission technology currently licensed under NRC's  
18 utilization facility frameworks.

19           This could provide the NRC staff the opportunity to develop  
20 a holistic, technology-inclusive, risk-informed and performance-based  
21 regulatory framework to specifically address the unique hazards and  
22 characteristics of fusion energy systems.

23           However, categorizing all fusion energy systems is  
24 utilization facilities is widely viewed by developers, non-governmental

1 organizations, and agreement state representatives as a burdensome option.

2           Categorizing fusion energy systems as utilization facilities  
3 would apply specific requirements in the NRC's regulations and the Atomic  
4 Energy Act. Examples of these include financial protection of the Price-  
5 Anderson Act, restrictions on foreign investment and ownership, mandatory  
6 hearings during the initial licensing process, specific export controls, operator  
7 licensing requirements, and prohibiting agreement state delegation.

8           These stakeholders also believe that a utilization facility  
9 approach would create regulatory uncertainty as the NRC staff initiates an  
10 extensive rulemaking to tailor a framework historically developed for fission  
11 reactors to the hazards posed by fusion technologies.

12           If the Commission decides that fusion energy systems do  
13 not meet Atomic Energy Act definition of a utilization facility, the second option  
14 for regulating fusion energy systems would employ the NRC's byproduct  
15 material framework.

16           If pursued, this option could build upon the licensing  
17 framework in 10 CFR Part 30 through a limited scope rulemaking along with  
18 the development of supporting regulatory guidance. This approach including  
19 references to 10 CFR Parts 30 through 39, 10 CFR Part 20 and other  
20 applicable parts of 10 CFR, could provide a broad scalable framework for  
21 regulating the use of byproduct material produced by fusion energy systems.

22           This approach has been successfully applied to current  
23 fusion activities by our agreement state partners and has historically been  
24 used to regulate radiological hazards from an extensive spectrum of uses of

1 byproduct material, from low-risk portable gauges to higher-risk panoramic  
2 irradiators that contain millions of curies of cobalt-60.

3           However, larger higher-hazard commercial fusion energy  
4 systems that differ from the characteristics we have described may require  
5 exemptions, license conditions, or orders to appropriately regulate under this  
6 approach, and may ultimately be determined to be utilization facilities.

7           The final option is the development of a hybrid approach that  
8 could address the differences in potential radiological hazards associated with  
9 a wide variety of fusion technologies and designs. A hybrid approach would  
10 introduce decision criteria to determine the appropriate regulatory framework  
11 using either byproduct material or utilization facility approach based on the  
12 potential risks and hazards.

13           Such decision criteria could be developed as part of a  
14 rulemaking process with significant stakeholder engagement and would need  
15 to be grounded in the Atomic Energy Act criteria defining utilization facilities.

16           This option would provide a graded approach for addressing  
17 potential risks that could encompass the full range of possible commercial  
18 fusion energy systems.

19           This approach would apply the appropriate set of  
20 requirements to safely regulate a given fusion technology commensurate with  
21 its risks and hazards and would include criteria to transition from a byproduct  
22 material framework to a utilization facility framework.

23           A drawback to the hybrid approach is the potential  
24 introduction of regulatory uncertainty for designs that approach the design

1 criteria.

2 To successfully implement this approach, the NRC staff  
3 would need to work closely with developers prior to the submittal of an  
4 application to affirm the appropriate licensing framework for a particular  
5 design.

6 In developing its recommendation to the Commission, the  
7 NRC staff is evaluating these options based on several key considerations  
8 including consistency with the Atomic Energy Act and Commission regulations  
9 and policy, framework scalability from current research and development  
10 facilities to expected commercial fusion energy systems, radiological and non-  
11 radiological hazards associated with operations and the radioactive material  
12 inventories for a variety of designs, ability to leverage requirements within  
13 existing regulatory framework that can legally and technically encompass  
14 proposed fusion energy systems and their associated hazards. And  
15 applicability and flexibility in certain programmatic areas such as financial  
16 protection under Price-Anderson, foreign investment, licensing process, and  
17 others.

18 I will now turn the presentation over to Dr. Joseph  
19 Staudenmeier to update you on the NRC staff's research efforts in preparing  
20 to regulate fusion energy systems. Joe?

21 DR. STAUDENMEIER: Thank you, Andrew. Good  
22 morning, Chair and Commissioners. I'm going to give a brief overview of our  
23 current and future activities to support the development of NRC capabilities to  
24 license and regulate fusion energy systems. Next slide, please.

1                   There are many private companies pursuing fusion energy  
2 with a wide range of concepts and expected timeframes. Several have plans  
3 to demonstrate the feasibility of their designs in the next few years. As this  
4 happens, some fusion companies will shift their focus from demonstration to  
5 the task of engineering and designing safe and reliable commercial plants.

6                   The NRC staff will establish an agile and responsive  
7 research program that stays current with the evolving technology to support  
8 the development of a technical basis for efficiently licensing and regulating  
9 commercial facilities. Our initial activities will focus on further enhancing our  
10 knowledge of the commercial designs to support the development of  
11 risk-informed and performance-based regulations and guidance.

12                   Although there are many different proposed fusion energy  
13 system designs, there are important technical areas that are common  
14 between them. For example, most of the designs will require a system to  
15 process and purify tritium. They will also require radiation shielding and have  
16 materials performance considerations. Other areas that are important to  
17 consider include assessing potential accident source terms, operating waste  
18 streams, and decommissioning and waste disposal.

19                   While the NRC staff has information about these areas, we  
20 continue to monitor changes that the industry may make as they scale up for  
21 commercial operations. Additionally, the NRC staff plans to participate in the  
22 development, review, and possible approval of design codes and standards.  
23 These codes and standards will increase regulatory predictability and if  
24 applicants adopt them, could streamline NRC Staff reviews.

1                   While we understand the hazards associated with the fusion  
2 technologies operating today, scaling up those technologies to commercial  
3 prototypes will introduce new systems with new technical challenges. The  
4 NRC staff will monitor the industry for those potential changes and respond in  
5 a timely manner to ensure that our expertise and analytical tools if needed are  
6 ready to evaluate the safety of larger commercial fusion energy systems.  
7 Next slide, please.

8                   To do that, the near-term focus of the NRC staff is to develop  
9 additional expertise on fusion technologies. We intend to mirror the  
10 successful approach used for developing advanced reactor expertise. This  
11 includes developing and offering training in general technical areas applicable  
12 to fusion technology and technology-specific fusion design training for  
13 concepts approaching commercialization.

14                  We are also conducting Agency-wide seminars to increase  
15 the NRC staff's knowledge base. The NRC staff held the first of these  
16 seminars on October 19th. That seminar provided a high-level overview of  
17 fusion energy systems, including basic physics of fusion reactions, fusion  
18 confinement schemes, technical areas of concern for regulation, materials  
19 issues, and environmental regulation considerations.

20                  We recognize there is a wealth of knowledge on fusion  
21 outside of the NRC. As Andrew discussed, the NRC staff has held public  
22 workshops to collect input from stakeholders and we will continue to engage  
23 with the fusion community to leverage their substantial work and knowledge  
24 related to fusion. The NRC staff will also interact with DOE, the agreement

1 state, university researchers, and the international fusion research and  
2 regulatory communities.

3 Finally, the NRC staff will continue to coordinate with the  
4 commercial fusion industry to understand detailed design information and  
5 deployment schedules as we develop a regulatory framework to license fusion  
6 energy systems in an efficient manner that protects public health and safety.

7 Thank you, I'll turn it back to Cathy Haney to wrap up today's  
8 presentation.

9 MS. HANEY: Thank you. As we've heard from both  
10 panels, it's an exciting time in the nuclear field as fusion energy continues to  
11 make significant technological progress towards becoming a viable energy  
12 source. The NRC staff has engaged stakeholders and is developing options  
13 for Commission consideration that reflect diverse viewpoints and address  
14 regulatory needs based on the state of the fusion energy industry.

15 We will look forward to your feedback on NRC staff proposal  
16 and direction to prepare regulatory framework for fusion energy systems.  
17 The NRC Staff will continue to prioritize stakeholder engagement while  
18 completing the regulatory infrastructure to support that direction.

19 In closing, I'd like to thank all of the panelists today, the NRC  
20 staff who supported preparations for the Commission meeting, as well as the  
21 NRC staff and agreement state representatives on the fusion energy working  
22 group. Our success would not be possible without them. Thank you again,  
23 Chair Hanson and Commissioners, for the opportunity to present today and  
24 we welcome your questions.



1 CHAIR HANSON: Thank you, Cathy. We'll begin again  
2 with Commissioner Crowell.

3 COMMISSIONER CROWELL: Thank you, Mr. Chair, and  
4 thank you to all of our panelists today for all the information you provided.  
5 Talking about a regulatory framework for fusion may not be as exciting as  
6 talking about the science and technology readiness of our first panel, but it's  
7 equally as important to get right. So, that's why everyone from the first panel  
8 stuck around. I think my first question is probably to Ms. Veil.

9 Can you, for my benefit, tell me from a safety,  
10 environmental, and public health risk perspective how currently proposed  
11 fusion energy facilities compare to advanced reactors, particularly non-light  
12 water advanced reactors?

13 MS. VEIL: Yes, you heard in the panel earlier and we  
14 stated it here too, fusion technologies and fusion energy systems don't use,  
15 possess, or produce any special nuclear materials. So, inherently, risks  
16 associated with that, hazards associated with that are expected to be lower  
17 because there's no special nuclear material.

18 For advanced reactors they're still using special nuclear  
19 material and they're still underneath the Part 50 or Part 52 framework because  
20 of the hazards that are associated and the whole framework that's built around  
21 new and advanced reactors. Whether they're close to current fission reactors  
22 or they're completely different, they're still using special nuclear material.

23 COMMISSIONER CROWELL: But if I understand it  
24 correctly, a fusion reactor could be nefariously used to create nuclear

1 materials that cause a proliferation risk, is that correct?

2 MS. VEIL: I wouldn't characterize it that way because I  
3 don't think that fusion facilities could even easily be adapted to be nefarious.  
4 There's no triggers in terms of imports or exports, domestically or  
5 internationally, for fusion energy systems. So, they are fundamentally  
6 different. I don't know envision a scenario, I'm not an expert but I have not  
7 heard of any literature or any expectations that fusion energy systems could  
8 be modified for nefarious intent.

9 COMMISSIONER CROWELL: When a fusion energy  
10 system loses power, my understanding is that it's passively safe so to speak.  
11 But how does it come back online? It's not like you can just use diesel  
12 generators like traditional light water reactors. So, what happens in the event  
13 of power loss at a fusion facility from the perspective of grid stability?

14 MS. VEIL: I'll start at a high level and that may be a Duncan  
15 question, to give you some details on how they come back. But my  
16 understanding is if there's some type of accident with a fusion energy facility  
17 that the plasma reaction is just going to stop. I talk with my hands so I'm going  
18 to show you.

19 The plasma will collapse, the tritium that's inside of the  
20 fusion reaction is going to be a fraction of what's on-site, but the energetic  
21 possibility of even getting something offsite is going to be so much lower  
22 because you already have a small fraction of tritium and then the reaction  
23 stops. You don't need special engineer features to cool down that system.  
24 Now, in terms of coming back on mine, I'd have to pass that over to Duncan.

1 MR. WHITE: Yes, as Andrea said, the reaction ends within  
2 a few seconds. If you have a disruption, it will end. So, you would just have  
3 to go through the startup sequence again to start the system back up again.  
4 You would have to start all over again, you would have to create the plasma,  
5 you'd have to inject fuel into the plasma and achieve conditions. One of the  
6 things that would happen if there was a disruption, yes, you will have decay  
7 heat the system will have to calibrate.

8 Again, it's a complex industrial apparatus and it has heat  
9 involved with it that will dissipate. So, I would assume that they would have to  
10 reach equilibrium before they would probably start up again.

11 COMMISSIONER CROWELL: So in layman's terms is that  
12 hours, days, weeks?

13 MR. WHITE: That I don't know, it's very design-specific, I'll  
14 have to defer that to the developers.

15 COMMISSIONER CROWELL: As we think of fusion and  
16 fission from a low-carbon but also base load power perspective, it's important  
17 to know how long you're going to be without that base load if something should  
18 happen in the system.

19 I'm sure there's probably limited ability for a fusion system  
20 to go offline and that's probably the more important point, but anything can  
21 happen. And it's something to think about and be interested in more as we  
22 learn more on that point. Thank you, Mr. Chair.

23 CHAIR HANSON: Thank you, Commissioner Crowell. I  
24 think you raised a good set of questions. This connection to the grid, on the

1 fission side we have this issue where if the secondary trips, we trip the primary  
2 in a lot of cases. Is there anything in a fusion energy system, whether you're  
3 talking about a DT system or some other thing, where it trips on the heat  
4 transfer side or the power generation side that then would impact the primary?  
5 From a safety perspective, not just from a flipping the switch perspective.

6 MR. WHITE: Like any complex system like this, complex  
7 energy system, you're going to have things that might trip the reaction.  
8 Again, to maintain the plasma in continuous mode is going to be a difficult  
9 thing to do. And again, there may be something that happens, it will trip.  
10 And again, what those causes could be, it could be a number of different  
11 things, sequenced things that could happen involving cooling or magnetics or  
12 something along those lines. There could be a number of different things and  
13 again, once you disrupt the plasma you lose your ability to generate neutrons,  
14 which in turn --

15 CHAIR HANSON: That's not considered to be safety-  
16 significant?

17 MR. WHITE: Again, these near-term systems that we've  
18 seen and studied, we have an understanding that they don't need special  
19 safety shutdown systems or require them to shut them down safely, they  
20 inherently will shut down by themselves.

21 CHAIR HANSON: Got it. So, one of the themes I think we  
22 heard in the first panel was the need for definitions and so how is the staff  
23 approaching that, either in the paper that we're going to see or subsequent to  
24 that?

1 MS. VEIL: So one of the things that you've heard in the first  
2 panel, and it's critically important, is to have clarity. So you've heard all of us  
3 say that these facilities could be regulated under a Part 30 framework, but Part  
4 30, and neither does the Atomic Energy Act, have any definition that talks  
5 about fusion energy systems. It doesn't exist.

6 So getting those definitions in there are extremely important.  
7 There is also content about the applications. We are always trying to be as  
8 clear as possible and set expectations up front so applicants know what to  
9 provide for us. So all of that will be detailed in the SECY paper, but it's  
10 critically important, and you heard about limited scope rulemaking, we need  
11 definitions. So that would be a part and the content of applications will be a  
12 part of limited rulemaking.

13 CHAIR HANSON: Okay. Thank you. I think it was Mr.  
14 Desai who in the previous panel had mentioned this Part 35.1000, which I  
15 think was we just had a Commission paper on this for emerging medical  
16 technologies, if I am not mistaken, as a potential model. So given the recency  
17 of Commission action on that front I was kind of curious if the staff had any  
18 reaction or thoughts, maybe even preliminarily, about a framework for  
19 addressing new and evolving technologies.

20 MS. HANEY: All right, I'll start. I actually can go back to  
21 when 35.1000 came to be in Part 35 in the '80s.

22 CHAIR HANSON: Yes.

23 MS. HANEY: It really was for that reason that we heard,  
24 was there were a lot of new emerging technologies into place. It didn't fit into

1 the existing Part 35 so the question was posed how could we create a  
2 regulatory framework to bring these technologies into play. It was exactly as  
3 described in an earlier panel. We would get applications in and we would  
4 start looking at them, deciding what we, you know, what as a regulatory  
5 agency we needed to have to move forward, to basically to issue that license  
6 such that we could go safely and we were assured of safety and security for  
7 the public as well as the workers.

8                   So the same situation really could apply here, you know, as  
9 described philosophically is that, you know, it probably wouldn't be, it wouldn't  
10 be a 35.1000, obviously.

11                   CHAIR HANSON: Right. Yeah, no.

12                   MS. HANEY: But that aspect of we have technologies that  
13 is emerging, industry is learning, we are learning, we are all getting smarter  
14 every day, even, you know, if you go back to when we wrote the White Paper  
15 to where we are right now. We are learning more, we're getting more  
16 informed, and we want to apply that as we develop that regulatory framework.  
17 Then as you get more, become aware of what you need, like, you know, we  
18 start with guidance, and then you can move into a regulatory framework. So  
19 that model I think would be, you know, definitely worth considering and  
20 philosophically I think it can be applied here.

21                   CHAIR HANSON: Okay, yes. Thank you. Sometimes  
22 adjacency is helpful as we think about these things rather than a complete  
23 blank sheet of paper, but I think that's been part of the theme here, too, is  
24 where does this fit into things we already know and things we know how to

1 regulate, so I think that's important.

2                   Cathy, I think you mentioned, and maybe in passing or very  
3 briefly, that staff is evaluating whether additional statutory authority might be  
4 needed under the Atomic Energy Act to facilitate the kind of appropriate  
5 regulatory framework. Do you want to kind of elaborate on that?

6                   MS. HANEY: I think I am going to actually defer to either  
7 Andrea or Andrew who has been a lot more involved in the discussions than I  
8 have been, but it would be clearly something, a lot of discussion in that  
9 particular area and depending upon which path that we go down it adds clarity  
10 and transparency to where we are going. So, Andrea?

11                   MS. VEIL: Sure, I can start. I saw Andrew raise, so he  
12 can add some detail as well. I mentioned earlier that the Atomic Energy Act  
13 has certain definitions in it. It doesn't say anything about fusion energy  
14 systems, but on the other hand it's also very prescriptive about what a  
15 byproduct material is. You heard it in the panel earlier. It talks about  
16 material that is made radioactive and used for either medical, commercial, or  
17 research.

18                   So if it doesn't fall into that framework, like you heard  
19 Duncan mention about aneutronic devices, it's incidental energy that is  
20 produced and that energy may not be used for anything commercial or  
21 research or medical.

22                   So then that falls outside the jurisdiction of the NRC  
23 because of a definition. So that could be easily, well I'm saying easily, but  
24 theoretically that could be revised.

1                   We talked about Part 30, just a few minutes ago, of how the  
2 definitions need to be in. Similarly, if we could make a recommendation for  
3 a legislative change it would make it that much more clear that fusion fits into  
4 the framework because, again, it doesn't, there is nothing that talks about  
5 fusion energy systems.

6                   MR. PROFFITT: Yes, and I will just add I think Cathy and  
7 Andrea said it well, but also with regard to the classified fusion energy systems  
8 as a utilization facility you would still run into this issue because the Atomic  
9 Energy Act current definition has for byproduct material a criteria for material  
10 that's made radioactive through the use of special nuclear material.

11                   So that's what brings in material that is made radioactive at  
12 commercial fission reactors. So you would still, the change would still be  
13 desired to ensure all this material was brought under NRC, clearly under NRC  
14 jurisdiction, regardless of which framework you went under. So it's not only  
15 a byproduct material issue, it would be also classified as utilization facilities.

16                   CHAIR HANSON: Okay. Thank you. Yes, I appreciate  
17 the discussion this morning and the staff panel and I appreciate the  
18 constructive approach that kind of everybody is taking to kind of this  
19 reasonably complex set of problems. I think it's really incumbent on us as an  
20 agency that we are not an impediment to kind of technological innovation in  
21 this area while we uphold our safety mission, you know.

22                   You guys hear me talk a lot of about chicken and egg  
23 problems, you know, fusion has a lot of the same ones that, you know,  
24 deployment of new fission does and I do think it's incumbent upon us as an



1 agency to, you know, address those chicken and egg problems within our  
2 purview as much as we can, as expeditiously and clearly as we can, so thank  
3 you again. Commissioner Baran?

4 COMMISSIONER BARAN: Thanks. Well, I wanted to  
5 start asking about a different but related definitional question actually, which  
6 is on particle accelerator. In the White Paper the staff did, the staff raised the  
7 concern that some fusion designs might not meet the definition of particle  
8 accelerator, which as I understand it is really determinative of whether or not  
9 you could use Part 30 as written for a particular design.

10 Can you all talk a little bit about that? What kinds of  
11 designs might fall out of that definition? Are those ones that are being  
12 thought about in the near term?

13 (Simultaneous speaking.)

14 (Laughter.)

15 MR. WHITE: I'll start. I think with regard to -- I think we  
16 have touched a little bit about this already about particle accelerators and  
17 byproduct material because they are both, you know, for proprietary, they are  
18 tied together, tied together, and I think we have talked, we've had discussion,  
19 talked a little bit about why it's important that the definition of particle  
20 accelerators have to be used for commercial, medical, or research purposes  
21 and we've talked about, you know, the limitations associated with that.

22 One of the key things that may happen with that definition  
23 and why particle accelerators, you know, inherently may present a challenge  
24 there is that the, for like particularly with aneutronic fusion you may think the

1 production of radioactive materials is not needed for, it's incidental to the  
2 overall reaction, it's not needed for the direct reaction.

3           Because of that it's -- So it doesn't meet the definition and  
4 because it doesn't meet the definition it provides a potential regulatory gap  
5 and this is why we have been, you know, talking about them, maybe the need  
6 to address the Act, change the Act, because if it's in the Act we can't fix it by  
7 regulation, obviously.

8           So that's really part of where we are coming from with regard  
9 to why that is. And, again, particle, you know, as I said, when the rulemaking  
10 back in, you know, for the Energy Policy Act and then the subsequent  
11 rulemaking in the mid-2000s we weren't thinking about fusion devices at that  
12 time. So it wasn't on either the Congress' mind or the staff that developed  
13 the regulations, oh, we shouldn't have to incorporate fusion devices into the  
14 regulatory, you know, framework and sort of trying to, so now we're left, you  
15 know, several years later trying to see how we can fit that in.

16           COMMISSIONER BARAN: Okay. Option 2B in the White  
17 Paper talks about a limited scope rulemaking, which we've talked about quite  
18 a bit, to explicitly address fusion in Part 30.

19           Can you talk a little bit about what the content of that rule  
20 would look like? Is it purely -- Is that just basically the definitions and content  
21 of application-type issues or is there something beyond that that the staff is  
22 contemplating when they think about Option 2B?

23           MS. VEIL: It is mainly the definition because no matter  
24 what framework we choose the definitions are important. So that limited

1 scope would be definitions and then specifics on content of application. That  
2 really is the main focus of that limited scope.

3 We may pull in other things that are more minor, nothing,  
4 you know, monumentally different, but if we're going to open it up and do a  
5 limited scope we might as well get all of this clarity in there, but not anything  
6 that's beyond just clarification.

7 COMMISSIONER BARAN: Okay. And when you are  
8 talking about content of application does that get at, you know, what would be  
9 required for a safety analysis for the hazard specific to fusion, is that part of  
10 content of application when we talk about it that way?

11 MS. VEIL: We weren't contemplating getting that specific  
12 in the limited rulemaking.

13 COMMISSIONER BARAN: Okay.

14 MS. VEIL: It would be more so the definitions, content of  
15 application, and then we'll probably get to this later, but I'll go ahead and  
16 introduce it now, that if we were then talking about a hybrid approach what  
17 would be design criteria to kind of trip that threshold.

18 Those are the types of things that we would think of in a  
19 hybrid approach, but for Part 30 itself it's the definitions and the content of  
20 applications not specific to safety hazards and things of that nature.

21 COMMISSIONER BARAN: So just to clarify, so if we were  
22 talking about, let's put aside hybrid for a minute and just talk about kind of Part  
23 30 and a limited scope rulemaking on Part 30 for more of a fusion module  
24 there, would there be clarity provided in such a rulemaking about what would

1 need to be shown on a safety analysis or is that simply not relevant for Part  
2 30? I would think it would be, right. You'd have to -- Whether it's tritium or  
3 whatever the other hazards are, activated material, to provide some real  
4 certainty and predictability to potential applicants about what do you need to  
5 show on those in an updated, you know, Part 30 approach.

6 MS. HANEY: I think it's more likely you're going to see that  
7 in guidance development.

8 COMMISSIONER BARAN: Okay.

9 MS. HANEY: You know, because typically in the rule if  
10 we're putting anything into a rule about what needs to be in a license  
11 application it's at a very high level. But really what the end users, including  
12 our staff, are interested in the guidance, the examples of what we are looking  
13 for, again recognizing there is a difference between guidance and a  
14 rulemaking, but I think that level of detail you would see more in guidance.

15 COMMISSIONER BARAN: Okay. Yes?

16 MS. VEIL: And I would just add to it at this phase it may  
17 not even be very prescriptive guidance, because remember we're kind of  
18 focusing on the near-term. To get to the type of analysis for maybe future  
19 fusion energy devices, we would need more certainty, more time, more  
20 operating experience, what have you, before we try to put out something that  
21 prescriptive, but we're not really concerned about that for the near-term  
22 devices.

23 COMMISSIONER BARAN: Okay. Yes, when we talk  
24 about near-term, I think on the first panel both Commissioner Caputo and I

1 were trying to get at this a little bit, you know, what are you thinking about in  
2 terms of timing? What is the timing you are envisioning for a limited scope  
3 rulemaking if we went down that path?

4 MS. VEIL: So if we went down the limited rulemaking path  
5 we're looking at about 18 months to get something in place for limited scope.

6 COMMISSIONER BARAN: Okay. Eighteen months for a  
7 proposal or --

8 (Simultaneous speaking.)

9 MR. PROFFITT: I was just going to add we're --

10 COMMISSIONER BARAN: That sounds so suspiciously  
11 short.

12 MR. PROFFITT: So we're certainly on the clock with  
13 NEMA to provide something by 2027. So the different paths we have looked  
14 at for the different options we have assessed, you know, how we could get to  
15 that point over the next several years. But certainly that's our goal is to meet  
16 the NEMA requirement of having a framework in place by 2027.

17 COMMISSIONER BARAN: Okay.

18 MR. WHITE: Yes, and that would include both rulemaking  
19 and guidance. Guidance, you know, would you have to be developed in  
20 parallel with any rulemaking. Guidance could be probably done quicker than  
21 the rulemaking if it was done by itself. That could be our 18, that in itself  
22 might be about 18 months just to do the guidance.

23 COMMISSIONER BARAN: Okay. Well, and that sounds  
24 like, 18 months sounds like more in line with potentially folks coming in to start

1 pre-application discussions, right, to have that guidance in place. That's how  
2 you are thinking about that?

3 MR. WHITE: Yes. In fact, with regard to guidance and  
4 reviews if we use the byproduct materials framework we have a good template  
5 in place with NUREG-1556, you know. It's scalable to a wide range of  
6 different uses from gauges up to panoramic radiators, there is particle  
7 accelerators in there, so there is plenty of basis to get started with and thinking  
8 we would pull in other, you know, guidance as needed, you know. There is  
9 separate decommissioning guidance and different NUREG and stuff like that,  
10 so it certainly would provide a good starting point to do that and it's very  
11 comprehensive, too.

12 COMMISSIONER BARAN: Okay. Well, and Joe talked a  
13 little bit about this in his presentation, but let me ask about NRC's capabilities  
14 and expertise when it comes to fusion.

15 Historically we haven't really focused on fusion because we  
16 have only ever licensed fission reactors. This is a broad question, but I'll ask  
17 it. It's the kind of thing you can answer in two minutes, I think.

18 (Laughter.)

19 COMMISSIONER BARAN: What technical expertise do  
20 we have now, what expertise do we need and when do we need it?

21 MS. HANEY: All right, I'll start with that one. So what we  
22 need is we're really looking at the engineering fields, the structural, the  
23 electrical, and the materials, the chemical, health physics, nuclear engineers.  
24 That's if I just do a very broad brush on what sorts, or what are the big, you

1 know, kind of the big hitters, and then there is, of course, a subset under that.

2 We do have those skillsets in house right now. They have  
3 been working on the project. Today you have heard what's going on in  
4 research. We have been involved with research. We have been involved  
5 domestically, as well as internationally, the different engagements. We have  
6 been working a lot in this area. Moving forward we probably need the same  
7 type of skills, but, you know, do we have those skills right now, do we have a  
8 gap.

9 I think, again, we are continuing to learn. Given the  
10 engagements that we have. I don't think there are any specialties we need  
11 to go out and hire or retain right now. Obviously, you know, I might give you  
12 a different answer in 2027, but for right now I think we just need to continue to  
13 grow the skills that we have right now, the individuals that we have right now,  
14 and make sure that they are getting the experience in fusion that we'll need  
15 them to have going forward.

16 COMMISSIONER BARAN: Okay. Well, thank you all for  
17 today's discussion. I thought it was good. Thanks for the White Paper. I  
18 am looking forward to the upcoming Policy Paper, and I know you are all hard  
19 at work at that, so thanks.

20 CHAIR HANSON: Thank you. Commissioner Wright?

21 COMMISSIONER WRIGHT: Thank you. Thank you very  
22 much. Good morning, or good afternoon, to each of you and thank you for  
23 your presentations.

24 This is a lot of information and there has been a lot as you

1 know going on and I am trying to kind of get things in the right order  
2 perspective and understand where things really are.

3           So, you know, you had the White Paper that came out in  
4 September. It was widely reported in the Trade Press and it even felt like you  
5 had kind of settled on maybe an option or a direction.

6           You've had numerous drop-bys and conversations and  
7 meetings with, you know, people internally and externally where the White  
8 Paper was concerned and there seemed to be general alignment, you know,  
9 with what had been reported in the Trade Press and with the conversations  
10 that the staff seemed to be aligned with the external stakeholders and some  
11 others as well on that and then we had the staff's response to the ACRS letter  
12 of yesterday.

13           So I am trying to understand just a little bit more. The  
14 conversation that you had here with Commissioner Baran was really good.  
15 That helped put some of that in some perspective, too.

16           So a couple things. One, can you speak a little bit about  
17 where you really are right now regarding this decision, okay, and which option  
18 to go, what framework to go, how to do this. Then, I am also wanting to  
19 understand, based on what I heard in the first panel there is a need to get the  
20 basic stuff done now so that they can get involved in pre-application and they  
21 can get moving on some stuff.

22           But then they are going to have to know at some point  
23 certain here that it's going to be under Part 30 or Part 3X or Part whatever,  
24 you know, because once you get, if you start mixing, as I heard in the first, you



1 mix Part 30 and then you go to Part 50, you know, that you're changing the  
2 rules of the game, right. So kind of speak to me a little bit about where you  
3 are right now on that on everything.

4 MS. VEIL: Sure. I can start and then others may want to  
5 add as we move forward. So Cathy kind of mentioned this earlier. First of  
6 all, I'll say what the first panel said, we appreciate ACRS' thoughtful  
7 consideration of this topic.

8 So I will be very clear on the things that we agree with and  
9 the things that we have disagreements with. The NRC staff and ACRS both  
10 agree that near-term, either, you know, facilities that are research or facilities  
11 of that nature, no question, they could be regulated under a Part 30  
12 framework, right. We also agree that there may be a threshold of where a  
13 fusion energy system is no longer a byproduct facility, it's a utilization facility.  
14 Where we disagree is what that threshold may be, right.

15 However, what you have heard today, Cathy mentioned it,  
16 the panel mentioned it, I mentioned it earlier, for the near-term fusion energy  
17 facilities that we have been studying for two years, that we have information  
18 on, and that we have been coordinating with our Agreement States,  
19 international partners, IAEA, we don't have concerns with the near-term fusion  
20 energy systems that with some tweaks, as you've heard for Part 30, that they  
21 could be regulated under a Part 30 byproduct material framework.

22 COMMISSIONER WRIGHT: Right.

23 MS. VEIL: But you also heard from our Agreement States  
24 speaker, who spoke very eloquently about this, we don't know what we don't

1 know. We have an opportunity here. If we are going to go forward with  
2 rulemaking, we can also have an approach that sets a framework, as you  
3 heard Sachin say, that later could be scalable. What Part that comes under  
4 we need to really assess that and look. But we have near-term and we have  
5 what comes in the future.

6                   Certainty is important for the near-term. You've heard a  
7 number of us say for near-term we don't have concerns about risk, we don't  
8 have concerns about common defense and security, proliferation, the kinds of  
9 import/export things we talked about earlier.

10                   So the certainty in my opinion is there, but that doesn't mean  
11 that if there is something that has a higher risk, higher hazard, or some design  
12 that comes down, you know, in the future that we can say definitively right now  
13 that it will never be a utilization facility.

14                   COMMISSIONER WRIGHT: Right. So I guess -- And  
15 you've gone to where I wanted to go a little bit. So if I understand right, if we  
16 go to a limited scope rulemaking, right, you're going to try to address these  
17 things early on some of this stuff and when you get to the more complex stuff  
18 or changes in design or changes in materials or changes in whatever comes  
19 down the pipe later, you're not going to hold things up and put it under one  
20 rule. You're looking maybe at doing a dual path, am I correct there?

21                   MR. WHITE: Right.

22                   COMMISSIONER WRIGHT: Okay. That's --

23                   MR. WHITE: Right.

24                   COMMISSIONER WRIGHT: Okay.

1 MS. VEIL: Yes. And I would characterize it even further  
2 to say that we would have specific decision criteria so that we're not making it  
3 up at the time when we get those applications.

4 COMMISSIONER WRIGHT: Right.

5 MS. VEIL: We're trying to have that certainty up front, but,  
6 again, we're not concerned about near-term fusion energy systems.

7 COMMISSIONER WRIGHT: Right. That's very helpful.  
8 Thank you. It brings a little clarity to me. Andrew, do you got anything to  
9 add to that?

10 MR. PROFFITT: Well, I was just going to add, you know,  
11 and if fusion succeeds, as I think many people hope it does, I don't think this  
12 will be the last Commission meeting or the last Commission paper on the topic.

13 COMMISSIONER WRIGHT: Correct.

14 MR. PROFFITT: I mean if we have a fusion energy  
15 industry in this country, you know, we'll be actively engaged and then, well,  
16 probably half that book maybe about fusion.

17 COMMISSIONER WRIGHT: Yes.

18 MR. PROFFITT: So I think starting now and focusing on  
19 near-term and given that certainty and meeting, sort of meeting the technology  
20 where it is and continuing to grow that framework that it is currently regulated  
21 under probably makes a lot of sense.

22 COMMISSIONER WRIGHT: Yes. And based on what we  
23 heard two years ago versus what we are hearing today, it's light years, right.  
24 If they are truly trying to hit it ahead of schedule like it appears they are I mean

1 there is a lot we got to do, you know. To Commissioner Caputo and  
2 Commissioner Baran's points, we need to, you know, the timing is really  
3 important for us to be, we want to be in front of this, right, I mean we certainly  
4 do. Thank you for that.

5 So, Duncan, just quickly for you, given that your Agreement  
6 State, you know, history and how well you, in your experience and working  
7 with our partners, do you have any additional thoughts to maybe what was  
8 added to what Megan talked about in the first panel at all?

9 MR. WHITE: Well, I think first I think I want to reiterate, you  
10 know, our engagement with the Agreement States has been valuable to, you  
11 know, get insights on the technology, you know. So they have been taking  
12 the lead on this and we really have learned an awful lot from them. As we  
13 work and develop options, you know, it was mentioned earlier, but we have  
14 had two State people on the working group, very, very helpful, very great input.  
15 We've had four government-to-government meetings. We've had actually  
16 talked to a number of different States and heard, you know, where they are  
17 with all this.

18 Again, many of them, you know, Megan mentioned earlier  
19 there is a limited number of States now actively engaged, but a lot of States  
20 are curious, you know, because it may, you know, be in their jurisdiction in the  
21 coming years and they want to learn more about it. So I think we've got some  
22 really good insights on that.

23 So I think in terms of – and we also -- I think there is a great  
24 deal of interest, you know, that Megan brought up and others, you know, we've

1 heard from the previous panel about regulatory predictability.

2 One of the things that I think the State Representatives are  
3 really interested in is, you know, the NRC get involved and be involved with,  
4 you know, develop guidance for emergency plan, accidents, accident  
5 assessment, and emergency, all the things that, you know, that are kind of,  
6 it's like, we really don't have anything in this area. We need this type of  
7 guidance in place so we can have some level of certainty going forward with  
8 that.

9 And, again, and this is I think the last thing, that we need to  
10 continue engaging with them. Again, you know, whatever path we take  
11 forward they will be sitting, you know, in the room with us, you know, working  
12 on that guidance or working on that rulemaking in the future.

13 COMMISSIONER WRIGHT: Yes.

14 MR. WHITE: I mean that goes without saying, because,  
15 again, from a national perspective they have, you know, they are the experts  
16 right now.

17 COMMISSIONER WRIGHT: Well, thank you for that.  
18 Thank you so much, Chairman.

19 CHAIR HANSON: Thank you. Commissioner Caputo?

20 COMMISSIONER CAPUTO: Hi, there. Thanks again for  
21 all your work preparing for this meeting. This is a pretty exciting time for us  
22 in a topic like this that, as my colleagues have mentioned, we haven't spent a  
23 lot of attention on historically.

24 But I have to admit I am still struggling with a little bit of

1 clarity here. So it sounds like what I am hearing from you is for the near-term  
2 technologies we can use Part 30, yes?

3 MR. WHITE: Yes.

4 COMMISSIONER CAPUTO: Okay. So then stepping  
5 beyond say the near-term, are the foreseeable technologies, technologies that  
6 we have heard about, studied, talked with, do we expect that those will also  
7 be able to fit under Part 30 or do we see some candidates that we think may  
8 exceed the bounds of what we can do under Part 30?

9 Because Andrea mentioned we don't know what we don't  
10 know and I am trying to figure out what we know because -- I am trying not to  
11 be comic here, but saying we don't know what we don't know really isn't much  
12 of a basis for doing what Andrew suggested, which is crafting a new rule by  
13 '27. So help me figure out what this middle ground is of the technologies that  
14 we are familiar with or know are out there and, you know, somewhat credible,  
15 not just ideas on the back of a cocktail napkin, but for the designs that we  
16 know are out there, are we seeing some that would challenge the paradigm of  
17 licensing under Part 30?

18 MS. VEIL: I'll start and then anybody else can chime in. So  
19 for what we have seen and what we have been engaging in in the last two  
20 years, all the literature, all the interactions that we have seen, we don't have  
21 concerns about the Part 30 framework.

22 However, if we didn't take this opportunity to look at some  
23 decision criteria that could be offsite dose, as our UK speaker said they are  
24 doing a bounding type of assessment because, again, they don't know what's

1 going to come in the future.

2                   If we didn't take this opportunity now, which as Andrew said,  
3 it could be refined later. We are doing this to be able to have the framework  
4 in place if we do get something that challenges that, but from what we have  
5 seen we don't see challenges at this point.

6                   COMMISSIONER CAPUTO: So have we done the  
7 bounding assessment for Part 30 enough to know the technologies will fit  
8 within that bounding assessment or are you talking about a bounding  
9 assessment that is theoretical for technologies that we really haven't seen and  
10 haven't considered?

11                   MS. VEIL: We have looked at the bounding assessment  
12 for Part 30 in terms of how we are going to move forward with some decision  
13 criteria. We are going to have more information in the Commission paper of  
14 how we are looking to do that, but in terms of something theoretical or going  
15 out to some other framework that's not what we are proposing.

16                   We are proposing to have design criteria for anything that  
17 may be beyond that. I know that's not a satisfying answer, but that's -- We  
18 don't have concerns about the near-term technologies. That's about the best  
19 way I can put it.

20                   COMMISSIONER CAPUTO: Okay. So in looking beyond  
21 the near-term technologies then, obviously I think we should be very focused  
22 on making sure that whatever we do is risk informed. Have you considered  
23 a graded approach like the integrated safety analysis used in Part 70?

24                   MS. VEIL: Yes. And I know either Andrew or Duncan can

1 provide more detail on what we considered.

2 MR. PROFFITT: Yes. So I think any framework that we  
3 were to build, you know, obviously I think we're talking about for near-term  
4 facilities proposing a limited scope rulemaking to bring them within Part 30  
5 and learning that as we go. Certainly without any licensing experience or any  
6 operating experience or even, you know, maybe at this point a proof of  
7 concept of a design not happening for a few years now, I think the staff feels  
8 like it would be premature to set out and try to establish a full new framework  
9 to address fusion energy systems.

10 So I think that's part of our recommendation, bringing in -  
11 let's continue under Part 30. The current designs that we see out there can  
12 fit under a byproduct material approach.

13 There is not necessarily a technological limit to what Part 30  
14 could do, you know. Right now it covers a broad spectrum from, Duncan  
15 mentioned, you know, low-risk portable gauges to a higher risk panoramic  
16 radio with a significant hazard.

17 So we don't see a potential unnecessary cap. The difficulty  
18 comes in when you are trying to apply fusion in the right place with the Atomic  
19 Energy Act that doesn't mention the word "fusion" within the Act. I think that's  
20 where the struggle comes into play and assigning it to a framework that neither  
21 one was built originally to accommodate fusion energy systems. One aligns  
22 well with the hazards and the materials and the types of equipment that is  
23 there at those facilities and that's where they are being regulated now. I think  
24 growing that framework and allowing it to scale as the industry matures and



1 evolves could serve us well.

2                   COMMISSIONER CAPUTO: So is the integrated safety  
3 analysis approach in Part 70 a possible option for doing that scalable graded  
4 approach?

5                   MR. PROFFITT: I think so. I think we would certainly look  
6 at, you know, what we have done in Part 53, what we have done in Part 70,  
7 areas where we have brought risk information, and the ISA, as you mentioned,  
8 and bringing that into a framework as we develop a more full framework that  
9 would support a fusion energy industry.

10                  COMMISSIONER CAPUTO: Okay. Thanks. I think that  
11 makes a fair amount of sense and that's certainly a technique or a process  
12 that we certainly have a fair amount of experience with.

13                  Dr. Staudenmeier, I want to indulge my inner geek here for  
14 a moment. I have a research-related question. Obviously, the Office of  
15 Research has been conducting future focus research. This technology I think  
16 is probably a candidate for some of those efforts. I want to ask you in  
17 particular about something. I noticed an article last week from MIT on how  
18 they are using machine learning to anticipate turbulence at the periphery of  
19 the plasma.

20                  I know Office of Research has been starting to look at AI.  
21 Is this, you know -- The most interesting engineering challenges are always at  
22 the periphery, which this is. Is this issue something that is important simply  
23 for the function of the machine or does this become, understanding this  
24 phenomena become important for us in regulatory decision making; and if so

1 are you folks looking at the nature of how they are using machine learning  
2 here to better understand those phenomena at the edge of the plasma?

3 DR. STAUDENMEIER: Thank you. I have actually seen  
4 that article I think that you are talking about, or some version of it I've seen. I  
5 don't think we're really too interested in the plasma physics models, excuse  
6 me, but we are interested in the effects that the plasma can have on the  
7 material interfaces and generating of dust. Another thing I know people use  
8 AI for infusion is to try to prevent disruptions, which can cause damage to the  
9 first wall also.

10 COMMISSIONER CAPUTO: Mm-hmm.

11 DR. STAUDENMEIER: So that would be a possible  
12 accident initiator that we would have to consider if we were looking at a safety  
13 analysis. So there are applications I think that are related to us but maybe  
14 not directly the plasma physics but the consequences of the plasma physics.

15 COMMISSIONER CAPUTO: Okay. Maybe particle  
16 transport? I am thinking of just the interaction with the walls of the machine.

17 DR. STAUDENMEIER: Yes. Well, the type of particle  
18 transport we'll be more interested in other than the materials interactions at  
19 the edge and we'll be interested in experiments that are looking at that and  
20 how the plasma affects the edge and generates dust or possible melting of  
21 the first wall material.

22 COMMISSIONER CAPUTO: Okay. All right, fair enough.  
23 I am going to take a minute, since I have one minute, and just ask a quick  
24 question.

1                   We focused a lot today on regulation and we focused a fair  
2 amount on safety. What we really haven't talked about much but  
3 Commissioner Crowell sort of broached the subject a little about security.

4                   So, obviously, not really much in the way of safeguards  
5 considerations because there is no special nuclear material, but is there  
6 anything that sets physical protection differently for fusion energy devices than  
7 we would see for particle accelerators under Part 30? Are there any different  
8 considerations here for physical security?

9                   MR. WHITE: I'll take a crack at that one. We did have  
10 discussions with NSIR regarding the physical security in fusion facilities.

11                   As you know, Part 37 was developed for a very particular,  
12 for RDDs and Radiological Exposure Device, REDs, and there is IAEA  
13 literature out there and documents that do have a look at a broad breadth and  
14 include additional isotopes, including tritium. Again, tritium was never  
15 considered under Part 37.

16                   So going forward and looking at a security standpoint we  
17 would have to, you know, start with what IAEA has and do that assessment,  
18 do that security assessment, with regard to what is going to be at these  
19 commercial fusion facilities and take a look at those and determine if we do  
20 need to have some sort of, you know, threshold values or something  
21 associated with that where physical protection is needed or something like  
22 that and we'll have to do that assessment.

23                   Again, there is information just to get started with what we  
24 have to go through and do that assessment to come up with --

1 (Simultaneous speaking.)

2 COMMISSIONER CAPUTO: Okay. But considering the  
3 types of materials present in a lot of particle accelerators I assume this kind of  
4 a review would be risk informed based on --

5 MR. WHITE: Yes.

6 COMMISSIONER CAPUTO: Okay.

7 MR. WHITE: Yes.

8 COMMISSIONER CAPUTO: Thank you. That's all I  
9 have.

10 CHAIR HANSON: Thank you, Commissioner Caputo. All  
11 right, thank you, everyone for a very, very good discussion. Thank you again  
12 to our external panelists, very wide ranging and I think very informative and I  
13 really appreciate all of the constructive engagement.

14 And, as always, thanks to my colleagues for their insightful  
15 and thoughtful questions. With that, we're adjourned.

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